State of New Jersey
Department of Environmental Protection

2024 NEW JERSEY STATEWIDE WATER SUPPLY PLAN

Draft for Public Comment

Acknowledgements

This update of the New Jersey Statewide Water Supply Plan, hereinafter referred to as the "Plan", represents a major advance in the state's protection of water resources and planning for future needs. Its publication is made with sincere thanks to Governor Phil Murphy, Lieutenant Governor Tahesha Way and Department of Environmental Protection (DEP) Commissioner Shawn LaTourette for their leadership and dedication to the stewardship of New Jersey's precious water resources.

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Table of Contents

2024 NEW JERSEY STATEWIDE WATER SUPPLY PLAN EXECUTIVE SUMMARY

New Jersey's water resources are essential public assets, held in trust for the people by the State Commissioner of Environmental Protection, and critical to the health, safety, economic wellbeing, recreational and aesthetic enjoyment, and general welfare of all New Jersey residents. The State's 9.3 million residents, $800 billion economy, and diverse ecosystems depend upon a clean, secure, and resilient water supply in order to meet daily needs, expand economic opportunities, enhance standards of living, improve public health, and restore the natural environment. Thus, the New Jersey Legislature, through the Water Supply Management Act (N.J.S.A. 58:1A et. seq), charged the Commissioner and our Department of Environmental Protection (DEP) with ensuring that water resources are planned for and managed as a common resource to provide an adequate supply and quality of water for present and future generations of New Jerseyans and to protect the natural environment of the waterways of the State.

With DEP oversight and support, public and private water supply managers have worked to successfully balance the needs of the state's residents, businesses, and environment and ensure that there is the necessary quantity and quality of water, when and where it is needed. However, new and increasing water supply challenges demand renewed commitment to New Jersey's progressive water supply planning and management approach. Among these challenges are water management risks stemming from our rapidly changing climate and its rising sea levels, warmer temperatures, and unprecedented precipitation variability; aging infrastructure in both small and large and urban and rural water systems; emerging water contaminants, including such as synthetic chemicals like per- and polyfluoroalkyl substances; and the occurrence of harmful algal blooms that endanger water supplies.

A coastal community and natural vegetation located in Brigantine, New Jersey.

In recent years, New Jersey has repeatedly faced a confluence of water resource challenges that have tested our infrastructure and the responsive capacity of our institutions. During the summer of 2022, extremely low precipitation and streamflow led the DEP to declare a Drought Watch, the first in more than six years. During the same period, aging infrastructure failed, resulting in massive water main breaks (two of which impacted more than 700,000 residents); water systems were required to confront supply sources contaminated with per- and polyfluoroalkyl substances (PFAS); and rampant harmful algal blooms (HABs) were worsened by extremely warm temperatures and intense precipitation. One such HAB broke records for duration, and its toxin levels threatened the water supply of 800,000 residents. The difficulties continued into 2023, with four months experiencing near record temperatures, the wettest December on record, continued infrastructure failures, and water systems struggling to remedy PFAS contamination.

The combination of these challenges has severely tested the resilience of New Jersey's water resources and their management and has proved especially vexing for the State's most vulnerable, underserved, and overburdened communities. As such conditions are expected to persist or worsen in the years ahead, the DEP and public and private water supply managers must carefully administer planning, regulatory, investment, and incident response initiatives. Conscious of these challenges and informed by multiple points of analysis, this 2024 New Jersey Statewide Water Supply Plan (Plan) identifies immediate, near-term, and long-term actions necessary to ensure that water supplies remain viable for current and future generations.

The Delaware and Raritan Canal at Swan Creek located in Lambertville, New Jersey.

This constitutes the third major Plan since the enactment of the Water Supply Management Act; it presents updated water supply data, adds several new points of analysis, and reflects the most current and best available science. It builds off of previous plans, and utilizes important DEP science, data, policy, and regulatory developments to assess resources and redefine critical actions and next steps.

Since the last Water Supply Plan revision in 2017, significant progress has been made in characterizing existing climate change impacts and projecting the magnitude and timing of continuing climate changes to better define how they will impact the State and its water resources. The challenges are great and evolving, but work contained in

this Plan provides the assessments and establishes the processes to enable public and private water supply managers to continue to meet the water needs of New Jersey's residents, economy, and environment. The 2024 Plan concludes that, under normal conditions and in most regions, the State has sufficient quantities of water to meet current and reasonably anticipated future needs. However, the continued availability of water resources and their readiness for use is dependent upon intentional and consistent actions to conserve, bolster, and actively manage public and private water supplies. In short, New Jersey is well-positioned to address its water supply challenges as long as the State, together with the multitude of water supply managers and water system owners undertake continuous actions to mitigate the risks of climate change, aging infrastructure, and emerging contaminants, including through the actions and policy supports identified here.

In meeting the seven key requirements of the Water Supply Management Act, this Plan identifies ground and surface water supplies and quantifies their current and projected demands; makes recommendations for improvements or additions to water supply facilities, for agricultural and aquacultures use; identifies policy supports necessary to protect source waters; and identifies land preserved for water supply purposes and administrative changes to improve ground and surface water quantity and quality.

In addition to addressing these key requirements, this Plan also includes a summary of the State's drought monitoring and response, a water conservation strategy, DEP's first meaningful review of climate change implications for statewide water supply and detailed actions to help address this challenge, an analysis of potential water availability losses due to contamination by contaminants of emerging concern, including the PFAS suite of chemicals and others such as 1,4 dioxane, and a review of how water supply issues intersect with environmental justice concerns. In addition, to supporting comprehensive management while capturing the diversity of water supply issues faced in different parts of New Jersey, this Plan offers assessments and recommendations from both a statewide and regional perspective, and provides guidance for state and regional water supply decision-makers.

Rapids on the Batsto River at Wharton State Park located in Hammonton, New Jersey.

To ensure that New Jerseyans continue to have an ample, reliable, and safe quantity and quality of water now and in the future, this Plan identifies the following action areas:

- **Hydrologic Data, Monitoring, Models, and Assessments**: The availability of long-term and real-time hydrologic datasets are critical pieces of information the DEP uses to quantify trends, characterize current conditions, and to build and calibrate models. This information is used to ultimately make informed decisions and to update future water supply plans.
- **Climate Change - Water Availability Research and Modeling:** This Plan and its recommendations benefit from the availability of sound and reliable climate change science. This science continues to evolve, and DEP will remain committed to monitoring new developments, with a particularized focus on the regional and local impacts of climate change upon New Jersey and its natural resources. As new and additional climate change data becomes available, it will be utilized to improve DEP water supply models and monitoring methods to more effectively mitigate and manage climate change impacts to water resources.
- **Climate Change - Infrastructure Resilience Recommendations:** DEP develops recommendations and establishes criteria to improve the resilience of water infrastructure and mitigate the adverse impacts of climate change upon the State's water supply, including through actions to reform relevant DEP policies, protocols, statutes, or regulations pertaining to water infrastructure assessments and modifications.
- **Regional and Statewide Water Supply Planning and Protection:** Water supply planning is a critical element to ensure that the State continues to have adequate supplies of acceptable quality to meet all current and future needs, and to balance human uses with ecological needs. Regional and statewide planning is adaptive and evolves as new information becomes available or issues emerge. The Plan prioritizes regions of New Jersey where future planning efforts should be focused.
- **Water Policy Modernization:** DEP is obligated and empowered to improve and protect water supply resources and water system infrastructure to ensure water availability and the delivery of safe drinking water to homes and businesses. In some cases, the federal and state laws and regulations that give rise to these obligations are fit for modernization to better position the State and its water providers to confront new and evolving water supply challenges.
- **Asset Management and Resilience:** Maintenance and improvement of infrastructure is key to effective and successful water supply management, and critical to ensure the State has access to clean and plentiful drinking water. Proper asset management can reduce water incidents and emergencies, limit disruptions to customers, and reduce long-term costs.
- **Policies and Priorities for Efficient Water Use:** The Plan identifies key policy priorities for the DEP as it continues to regularly re-evaluate new technologies and research to ensure the responsible and efficient use of the State's water resources.
- **Public Outreach:** DEP is committed to continuing public education and engaging with people and communities we serve on key water supply issues and initiatives.

New Jersey residents, communities, businesses, and institutions are as connected and interdependent as the water resources we share, and each of us must be careful stewards of this precious, finite resource. As public and private water supply managers work to implement the measures identified in this Plan in the years ahead, DEP stands as a partner to every community, water system, business, institution, and member

of the public we serve. As DEP does its part to discharge the recommendations made here, the Department will closely monitoring new developments and update this Plan periodically to ensure that the most up-to-date data and best available science are utilized to address our water supply needs and challenges.

Together, we will ensure that current and future generations of New Jerseyans have access to a clean, secure, and resilient supply of water.

Pedestrian Bridge over Delaware River at Bulls Island Recreation Area, Stockton NJ.

CHAPTER 1: INTRODUCTION

For over a century, public and private water supply managers, have worked to balance the water needs of New Jersey residents, businesses, and environment to ensure that there is the necessary quantity and quality of water when and where it is needed for current and future populations. This is a core mission of the New Jersey Department of Environmental Protection (DEP) and the primary goal of the New Jersey Statewide Water Supply Plan (Plan).

Pakim Pond located in Brendan T. Bryne State Forest in the NJ Pinelands.

New Jersey has historically seen itself as a water-rich state with a relatively even distribution of precipitation over the seasons, especially as compared to other parts of the United States that experience water scarcity. New Jersey is also the most densely populated state in the nation, which places intense demands on our water resources, requiring thoughtful water supply planning and proactive management. New Jersey's water supply reservoirs are comparatively small and, during droughts, these and other water resources can become stressed. Our shallow groundwater in unconfined or surficial aquifers can serve an excellent water supply purpose, yet this resource is critical to healthy stream flow that in turn supports ecosystem health and downstream water supplies. The deep groundwater in New Jersey's confined aquifers can serve as a prolific water supply, but this vital resource can be stressed by excessive withdrawals and, in some areas, by saltwater intrusion. While water supply managers have ably navigated these needs and limitations in years past, emerging challenges—especially those exacerbated by our changing climate—present new and unprecedented levels of additional stress for our State's water resources.

Since the last Plan revision in 2017, significant progress has been made in characterizing existing climate change impacts and projecting the magnitude and timing of continuing climate change impacts. This 2024 Plan is part of a statewide effort to better identify the adverse impacts of climate change and plan adaptation measures. The challenges are great and evolving, but work is underway to provide the assessments and to establish the processes that will enable public and private water supply managers to continue to meet the water supply needs of its residents, economy, and environment.

In New Jersey, the waters of the state are owned by the people – all residents, both current and future - and are held in trust by the State for their benefit. The State government manages these waters on behalf of the people, through the Water Supply Management Act (N.J.S.A. 58:1A), which empowers DEP to allocate water resources to various needs through a formal process that ensures the demands are reasonable, that other water users are protected, and that the demands do not unduly diminish environmental quality. New Jerseyans have a reasonable expectation that statewide water supply resources will be sufficient to meet existing and future needs through both a planning and a regulatory process.

As directed by the Water Supply Management Act, DEP prepares and routinely updates a New Jersey Statewide Water Supply Plan that analyzes relevant water supply data, examines growth projections, evaluates risks, and

identifies policy supports necessary to overcome water supply challenges and ensure that New Jersey's present and future water resource needs can be satisfied. The first Plan was adopted in 1982, and major revisions followed in 1996 and 2017, with intermittent updates between revisions. This Plan constitutes the third major revision of the Plan; it presents updated water supply data, adds several new points of analysis, and reflects the most current and best available science. This Plan is to be revised and updated in five years (2028), consistent with the requirements of the Water Supply Management Act, but components may be updated prior as DEP intends this Plan to be a dynamic, living document: the data within will be updated on an ongoing basis as new information and analyses become available and scientific methods are refined and incorporated.

Several chapters of this Plan provide information and analyses that correspond to the multiple charges of the Water Supply Management Act, as follows:

Charge	Chapter and Summary
Identification of existing Statewide and regional ground and surface water supply sources, both interstate and intrastate, and the current usage thereof."	Chapters 2 and 4: New Jersey receives considerable precipitation, has significant ground and surface water sources, and sufficient storage capacity. Additionally, historic investments in water supply storage, transmission infrastructure, and interconnections have proven to be advantageous to the State for both normal and periodic drought and water emergency conditions, generally.
Projections of Statewide and regional water supply demands for the duration of the plan.	Chapter 4: Presents projections and includes forecasts for Public Community Water System (PCWS) demands to the year 2050, with the methodology and detailed results in the corresponding appendix. This Plan takes the additional step of providing conservative estimates of excess or shortfalls by Watershed Management Area (WMA). Results are presented in a regional, resource-specific manner making its usefulness in a site-specific manner limited, as water availability is a function of all water resources in a specific area and potential of site-specific resource limitations.
Recommendations for improvements to existing State water supply facilities, the construction of additional State water supply facilities, and for the interconnection or consolidation of existing water supply systems, both interstate and intrastate.	Chapters 5, 6, 7, and 8 present various strategies and recommendations, the implementation of which must be carefully planned based on sound scientific data and thoughtful analyses.
Recommendations for the diversion or use of fresh surface or ground waters and saline surface or ground waters for aquaculture [agricultural] purposes.	Chapters 5 and 6 include discussions of demand for these uses and guidance for future use, both on a statewide-basis and for specific WMAs.
Identification of policy supports that provide for the maintenance and protection of watershed areas.	Chapter 5 describes ongoing efforts to protect vital watersheds and potential avenues for expansion or enhancement of the Source Water Area Protection planning process.

Charge	Chapter and Summary
Identification of lands purchased by the State for water supply facilitates that are not actively used for water supply purposes.	Chapter 5 and Appendix L present this inventory and provide recommendations as to the future use of these lands for water supply purposes.
Administrative actions to ensure the protection of ground and surface water quality and supply sources.	Chapter 5 provides an overview of water resource protection and planning efforts and approaches for appropriate actions.

In addition to meeting these charges, this Plan also includes:

- a summary of New Jersey's drought/emergency strategies in Chapter 7, including active monitoring, management area designations and authorities to act in the event of a water supply emergency (this includes "lessons learned" from extreme weather events, including the multiple named tropical storms and numerous extreme precipitation events exacerbated by climate change as well as the historic and recent droughts and 'flash drought' extreme dry periods);
- a comprehensive statewide water conservation strategy, presented in Chapter 5 (Increasing Water-Use Efficiency);
- the first extensive review of climate change implications for water supply in New Jersey (Chapter 3), regarding water availability and the resilience of water supply systems, along with a discussion of managing water supplies in the face of uncertainty from droughts, climate change, severe weather events, energy costs, development patterns and demand trends (Chapter 7);
- an analysis in Chapter 2 of potential water availability losses due to contamination by contaminants of emerging concern, including the PFAS suite of chemicals and others such as 1,4 dioxane; and
- a review of ways in which water supply issues raise or address concerns for environmental justice and overburdened communities, in Chapter 5.

This Plan promotes improved asset management, targeted investment in existing infrastructure and new projects that will improve the interconnection and operability of existing water supply assets. Investment in water infrastructure is also needed to enhance the ability of systems to withstand and quickly recover from loss of service (e.g., water main breaks) caused by adverse conditions such as extreme weather events and unexpected water supply emergencies.

Challenges identified in this Plan include, but are not limited to:

- shifts in residential populations, energy production and industry base, making projections based on historic trends more difficult;
- growth of consumptive water use;
- potential implications of climate change for water availability, water quality and water system resilience;
- the need for better integration of water supply issues with environmental justice concerns, such as the potential for surface water and ground water quality issues affecting overburdened communities with limited financial capacity to ensure the best protections for public health;
- finished water losses from aging transmission infrastructure;
- the need for asset management and for water systems to invest in water supply infrastructure and associated funding challenges;
- additional costs attributed to water systems associated with increasing water quality improvement needs;

- risks from times of drought and unpredictable weather and the impact to water supplies and demands; and
- the time and resources necessary to fully implement the identified policy supports.

Through active and thoughtful water supply management, New Jersey is well-positioned to overcome these challenges, expand economic opportunities and improve standards of living—each dependent upon on safe and secure water supplies—and better protect and improve its water resources. As described in this plan, a key to such positive outcomes is to increase water use efficiency through conservation and effective management. Another key is to ensure that water systems continually invest in their infrastructure and consistently apply sound asset management practices that factor in changing risks profiles, including those resulting from aging infrastructure and emerging risks such as climate change. In doing so, New Jersey's water systems will become equipped with the decision-making tools necessary to prioritize the replacement of antiquated infrastructure and make priority-based decisions on investments in new infrastructure.

This Plan concludes that, while facing new and increasing water supply challenges, New Jersey has sufficient quantity of water to meet current and reasonably anticipated future needs in most regions of the state, but the continued availability and transferability of water is dependent upon intentional and consistent actions to conserve, bolster, and actively manage public and private water supplies, including through improvements to the policy supports identified in this Plan. In some regions (the Lower Raritan-Passaic region and the Southwestern region including WMA 17), there is concern that current or projected demands may exceed long-term available water resources during drought conditions; however, as discussed in this Plan, further analysis is necessary to better characterize these concerns.

The impacts of climate change upon New Jersey's water resources demands the continuous attention and vigilance of public and private water supply managers. DEP provides an initial evaluation of the impacts of climate change upon water supplies as part of this Plan and, while these initial analyses do not indicate severe impacts to water supply in the short-term, it is critical to acknowledge the improving accuracy of the climate change projections, including for future precipitation, temperature, and sea-level rise conditions—each of which carry serious implications for water supply. These improved projections and their associated water supply impact assessments may alter these findings and will likely require additional actions in the years ahead. As such, this Plan must be updated on a periodic basis to ensure that the most up-to-date data and best available science are utilized to make recommendations and address any newly identified concerns.

East Point located on the Delaware Bayshore near the mouth of the Maurice River.

Members of the public expect that their increasing water supply needs will be readily met. Ensuring that these expectations are met will be challenging, but must be considered a top-priority for the overall health and well-being of New Jersey's residents and businesses. This Plan is expected to serve as a key tool for DEP and various government agencies to inform enhanced management of one of New Jersey's key assets, its water supply.

In accordance with the Act, preparation and revisions of the Plan were conducted in consultation with many entities, including but not limited to the Water Supply Advisory Council, which includes a wide variety of water interests, the Highlands Water Protection and Planning Council, the Pinelands Commission, the New Jersey Water Supply Authority, the New Jersey Infrastructure Bank (pending), the Department of Agriculture, the New Jersey Environmental Justice Advisory Council, and many other water interests through a Water Supply Plan Stakeholder Advisory Group. A new website for the Plan (NJSWSP website) was also developed which provided additional opportunities for the public to participate in the planning process. In addition, in accordance with the Act, DEP released a draft version of the proposed Plan in February of 2024, collected public comment through April of 2024, held two public meetings during the public comment period both online and in person, and invited written comments on the draft Plan, all to allow additional public comment. All submitted comments have been evaluated and, where appropriate and practicable, changes were made to the Plan.

The general structure of the following Plan chapters is as follows:

Executive Summary

Chapter 1: Introduction

Chapter 2: Statewide Water Availability

Chapter 3: Climate Change and Water Availability

Chapter 4: Statewide Water Demands and Balances

Chapter 5: Water Resource Protection and Planning Efforts

Chapter 6: Regional Planning for Deficit Mitigation and Avoidance

Chapter 7: Planning for an Uncertain Future

Chapter 8: Water Supply Action Plan

Appendices: A series of twelve technical reports and other informational documents that provide detailed analyses, results, and issues in support of this Plan.

CHAPTER 2: STATEWIDE WATER SUPPLY AVAILABILITY

Table of Contents

OVERVIEW

Understanding where water supplies are adequate or inadequate to address current and future demands requires clear analysis of both natural water availability, water quality, and the built infrastructure (e.g. reservoirs) necessary to store water. The analysis of current and future water supply availability has five components:

1. Natural water-resource availability: A quantification of how much water can be withdrawn without causing adverse impacts. This is a function of water availability from three different sources:
    - surface-water reservoir supply systems;
    - unconfined aquifers and associated streams; and
    - confined aquifers.

Additional limits on natural water resource availability can also occur due to uncertainties with measurements or from water quality requirements which permanently or temporarily reduce availability.

2. Administratively approved availability: A quantification of the water that can be withdrawn in compliance with current DEP permits. In scenarios for water demands, these are the "full allocation" volumes.
3. Current and future water demands: The volume of water currently used and estimates of what will beneeded to meet residential, commercial, industrial, agricultural and other demands, either self-supplied or through public water systems. These demands are projected for all uses and geographic areas to ensure adequate supplies.
4. Future impacts to natural water-resource availability: Impacts include, but are not limited to, climate change impacts to supply and quality, new and emerging contaminants, and development and land use changes.
5. Water balance analysis: An accounting of the extent to which currently available supplies are sufficient or not sufficient to meet current and future needs.

The Great Falls of the Passaic River located in the Paterson Great Falls National Historic Park in Paterson, New Jersey. Paterson is considered America's first planned industrial city and was built centered around the Great Falls.

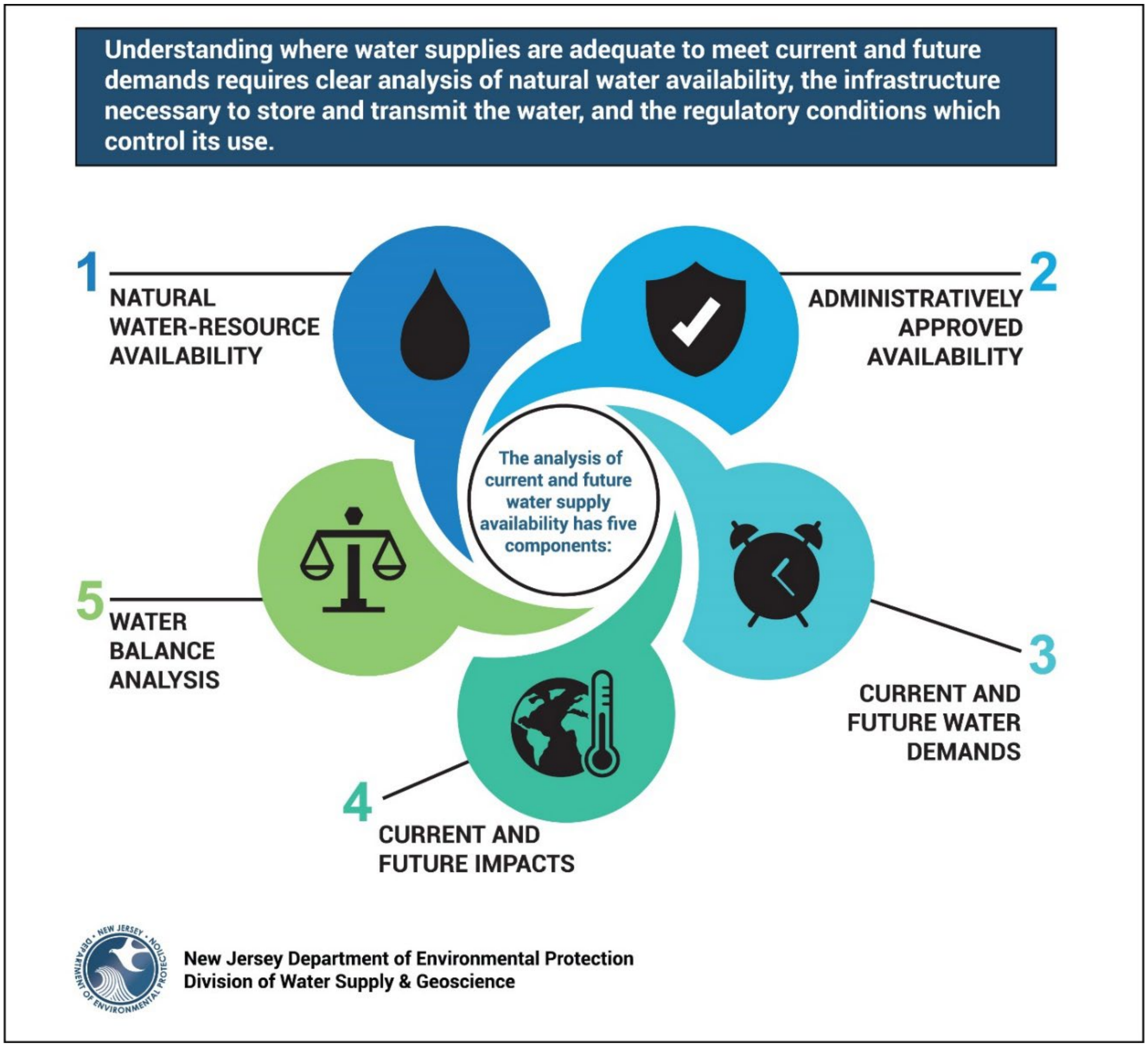

Figure 2.1 Infographic showing steps completed to develop the water availability analyses conducted in this Plan.

This chapter focuses on the first two issues described in Figure 2.1, while Chapter 3 addresses climate change and water supply and Chapter 4 addresses current and future demands and water balances. The general intent since the 1981 Water Supply Management Act is that DEP should ensure that new or modified water allocations and certifications do not impact existing water uses or environmental resources, based on available knowledge. Ideally, approvals should remain within the total water availability for a resource, but legacy approvals and lack of complete information are constraints to effective decision-making; the planning process provides an approach for addressing such issues. More information is available in the supporting documentation listed at the end of this chapter.

The goal for water supply planners is to establish strategies to ensure that water supplies, as well as necessary water supply infrastructure, are in place and coordinated to meet anticipated future demands. The planning process addresses both the need to ensure that water supplies are sufficient and the need to ensure that demands are not excessive, through efficient and effective water uses. However, the Plan is not intended to, and cannot comprehensively address every issue related to water supply. It does not address individual water allocation, certification or registration requests or expectations, as they are addressed through the Water Allocation permit process. These permit decisions, however, must be consistent with the overall guidance of the Plan. It also does

not address items regulated by the federal Safe Drinking Water Act and New Jersey Safe Drinking Water Act, though the Plan does evaluate issues related to the protection of untreated water resources (i.e., source water protection) and the potential loss of water supplies to contamination. Finally, the Water Supply Management Act specifically requires that no DEP actions, which includes the Plan, “shall be inconsistent with the provisions of the "Pinelands Protection Act," P.L.1979, c.111 (C.13:18A-1 et seq.), ... the "Highlands Water Protection and Planning Act," ... or the Highlands Regional Master Plan.” Therefore, these regions are addressed in a different manner than the rest of the state. Ultimately, this revision of the Plan is intended to be a major step forward in how DEP will evaluate statewide water availability in the future.

NATURAL WATER RESOURCE AVAILABILITY

Fresh water is withdrawn from many sources in New Jersey, each with differing characteristics which contribute to how withdrawals affect other users and the environment. Ultimately all water is connected via the hydrologic cycle. However, for planning purposes the DEP defines three unique but interconnected categories of water sources: (1) surface-water reservoirs with a defined safe yield; (2) stream and river intakes and unconfined aquifers; and (3) confined aquifers. While hydrologic connections exist between each of them, this Plan treats them as distinct categories of sources to allow for use of existing models and methods, including confined aquifer groundwater, reservoir, and groundwater recharge models, to better define how much is available and can be used. The 2017 Plan used a similar approach. Where potential or existing water deficits are identified in a region with more than one of these water supply resources, region-specific analyses can evaluate the interconnection among resources to provide a more robust availability analysis. Note that the confined aquifers as discussed in this document refer to the coastal plain confined aquifers, but not to any smaller or locally confined aquifers that occur outside of the coastal plain physiographic province. Note that surface water is often summarized as “SW” throughout this plan and should not be confused with stormwater. Groundwater is often summarized as “GW” with unconfined and confined abbreviated as “uncon” and “con”, respectively.

SURFACE WATER SUPPLY RESERVOIR SYSTEMS

Surface water supply reservoir systems are built to store raw (untreated) water accumulated during relatively wet periods for use when supplies may not be as plentiful. The construction of major water supply reservoir systems in New Jersey began in the 19th century, with many of the major urban areas building reservoirs in rural areas during the 1890s and early 1900s. Another spate of reservoir construction occurred in the post-war era of the 1950s and 1960s to supply the expanding population of New Jersey, especially in suburban areas, and in response to the severe 1960’s drought, often referred to as the drought of record, which reduced the amount of water that systems were previously believed to be able to provide. The largest of these were Round Valley and Spruce Run Reservoirs, the state’s largest and third largest in storage. The final major reservoirs were constructed around 1990, Monksville and Manasquan, to address needs in north Jersey and Monmouth County, respectively. The major water supply reservoirs are shown in Figure 2.2 and described in Table 2.1. The state’s reservoirs are primarily located in the northern and central regions, including a few relatively small ones located in northern New Jersey and the northern coastal plain region. Most of the coastal plain region of southern New Jersey is too flat for major reservoirs.

On-stream reservoirs are built across the path of a stream or river where the topography is favorable to impound water. The total amount of water an on-stream reservoir can provide for water supply is a function of the flows entering the reservoir from the upstream watershed, the capacity of the impoundment, and required releases. Most New Jersey reservoirs are of this type. Examples include Spruce Run Reservoir in Hunterdon County, Boonton Reservoir in Morris County, and Swimming River in Monmouth County.

Off-stream reservoirs generally are built on relatively smaller streams that can be dammed to form a large storage pool. They are then filled primarily by pumping from a larger stream or river nearby. Round Valley Reservoir, in Hunterdon County, and Point View Reservoir in Passaic County are examples of this type of reservoir.

Round Valley Reservoir located in Round Valley State Park in Lebanon, New Jersey. This reservoir is considered the largest reservoir in New Jersey and can hold up to 55 billion gallons of water at full capacity.

Finally, the yield of some on-stream reservoirs is increased by replenishing it with pumping from another water source. For example, the Wanaque Reservoir dams the Wanaque River, but water can be added to the Wanaque Reservoir through large pump intakes on the Ramapo River near the confluence of the Pompton and Passaic Rivers; the latter also provides water to Oradell Reservoir in Bergen County. Appendix B has information on the major surface water supply reservoir systems in New Jersey.

The safe yield of a reservoir system is the volume of water the reservoir system can routinely supply during a repeat of the driest conditions yet experienced. For New Jersey, this “drought-of-record” is often, but not always, the multi-year drought of the mid-1960s. A reservoir system’s safe yield is a function of the water flowing into the reservoir, the infrastructure available to store and pump that water, and the operating rules which govern reservoir operation, such as requirements for the reservoir to provide downstream flows. If the reservoir is modified by increasing its storage, its operating rules change, or release requirements change, then the safe yield may change. Refer to the DEP’s Guidance Manual for Estimating the Safe Yield of Surface Water Supply Reservoir Systems for more information (DEP 2011).

To address the complexities of reservoir system operations and interconnections, the DEP determined that a computational model was necessary. The model was developed in a software program called RiverWare which was created by the University of Colorado’s Center for Advanced Decision Support for Water and Environmental Systems (CADSWES). The model has been developed and added to over the years and is used for planning, permitting, and drought preparedness.

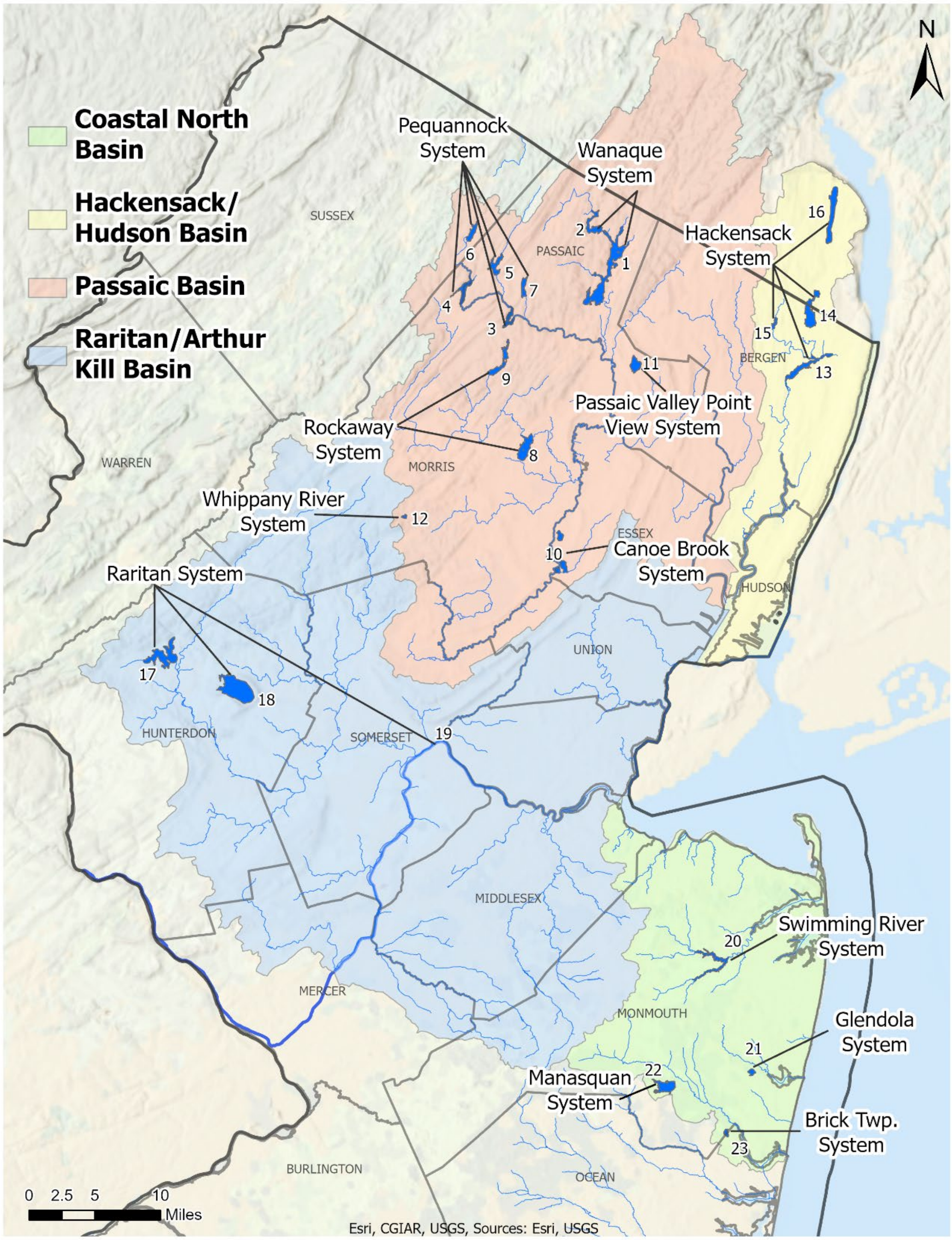

Figure 2.2 Major Surface Water Supply Reservoir Systems.

Table 2.1 Major Surface Water Supply Reservoirs that Serve New Jersey

Map ID Reservoir Name (approximate year completed)	Reservoir Owner	Usable Storage (bg)	Water Source
Wanaque System			
1. Wanaque (1927)	North Jersey District Water Supply Commission (NJDWSC)	29.49	Wanaque River; pumping from Pompton River (co-owned by Veolia North American) and Ramapo River
2. Monksville (1987)	NJDWSC	6.86	Wanaque River
Pequannock System			
3. Charlotteburg (1961)	City of Newark	2.41	Pequannock River
4. Oak Ridge (1892)		3.91	Pequannock River
5. Clinton (1892)		3.51	Clinton Brook
6. Canistear (<1900)		2.41	Pacock Brook/Pequannock River
7. Echo Lake (natural)		1.60	Macopin River
Rockaway System			
8. Boonton (1904)	City of Jersey City	7.10	Rockaway River
9. Split Rock (1948)		2.90	Beaver Brook
Canoe Brook System			
10. Canoe Brook #1, 2 & 3 (1900-1958)	New Jersey American Water (NJAW)	2.45	Canoe Brook/Passaic River
Passaic Valley Point View System			
11. Point View (1964)	Passaic Valley Water Commission (PVWC)	2.85	Pumping from Pompton River
Whippany River System			
12.Clyde Potts Reservoir (1930)	Southeast Morris County MUA (SMCMUA)	0.4	Whippany River
Hackensack System			
13. Oradell Reservoir (1921)	Veolia North American (formerly SUEZ)	3.27	Hackensack River
14. Lake Tappan (1966)		3.85	Hackensack River
15. Woodcliff Lake (1905)		0.87	Pascack Brook
16. Lake DeForest (1956)		5.37	Hackensack River
Raritan System			
17. Spruce Run (1964)	New Jersey Water Supply Authority (NJWSA)	11.0	Spruce Run and Mulhockaway Creek
18. Round Valley (1960)		55.0	Pumping from South Branch of the Raritan River
19. Delaware & Raritan Canal (repurposed 1950s)		n/a	Delaware River
Swimming River System			
20. Swimming River (1901)	NJAW	1.8	Swimming River
Glendola System			
21. Glendola (1965)	NJAW	0.9	Shark River/Jumping Brook
Manasquan System			
22. Manasquan (1990)	NJWSA	4.7	Timber Swamp Brook (direct), Manasquan River (pumping)
Metedeconk System			

Map ID Reservoir Name (approximate year completed)	Reservoir Owner	Usable Storage (bg)	Water Source
23. Brick Township (2005)	Brick Township MUA	0.9	Pumping from Metedeconk River

Table 2.2 Safe yield and demand for Major Surface Water Supply Reservoirs that serve New Jersey

Reservoir System	System Owner	Permitted Safe Yield (mgd)	Current Average Annual Demand (mgd)
Wanaque System	NJDWSC	148*	106
New Jersey Hackensack System	Veolia NA	126.5*	94
Pequannock System	City of Newark	49.1	25
Rockaway System	City of Jersey City	56.8	40
Canoe Brook System	NJAW	10.8	7
Passaic Valley System	PVWC	75	48
Raritan System	NJWSA	241	176
Swimming River System	NJAW	25	23.3
Glendola System	NJAW	5.7	3.7
Manasquan System	NJWSA	30	23.7
Metedeconk System	Brick Twp MUA	17	8.1
TOTAL		**784.9**	**554.8**

*Reflects shared ownership of the Wanaque South Project

SURFACE-WATER AND UNCONFINED AQUIFERS

An unconfined groundwater aquifer (also referred to as a water-table aquifer) interacts with the soils and surface waters above it. Water recharges the unconfined groundwater aquifer through the overlying soil, beyond the root zone of plants. Groundwater in some areas may not exist in sufficient quantity or quality to be usable as drinking water supply or for other purposes. Where groundwater levels are high relative to a nearby surface water body, groundwater moves toward the surface water (Figure 2.3a). Where groundwater levels are low relative to the surface waters, leakage from the surface water can recharge the unconfined groundwater aquifer.

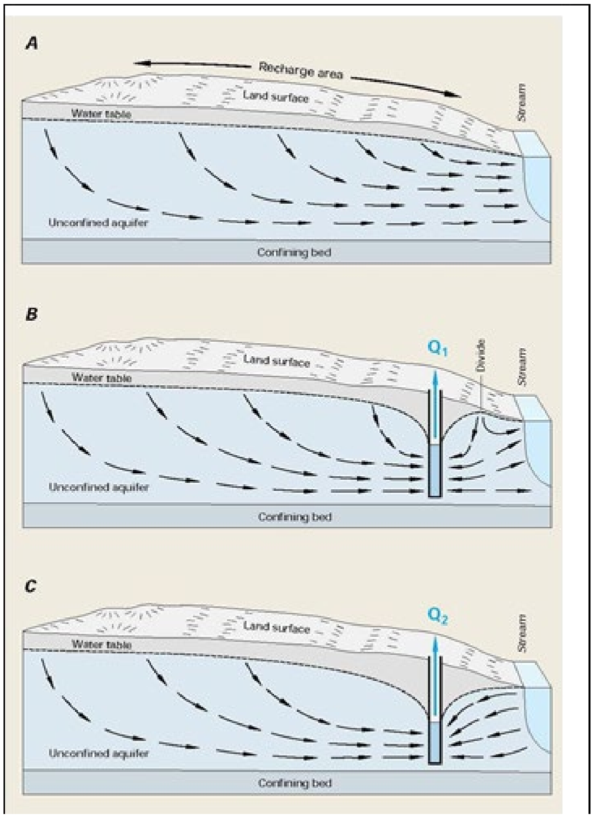

Figure 2.3 Unconfined Groundwater and Stream Flow: (a) natural conditions; (b) diverted by a pumping well; and (c) as diverted by a pumping well with induced stream leakage (modified from Winters et al., 1998).

Groundwater withdrawals from an unconfined aquifer can capture part of the water movement from groundwater to surface water (Figure 2.3b) or even reverse the flow direction and induce leakage (Figure 2.3c). The result is a reduction in stream flow, similar to a direct withdrawal from a stream but with a slower impact on flows. Therefore, when calculating water availability, withdrawals from unconfined aquifers are combined with withdrawals from surface-water intakes (other than those supported by reservoir storage).

Availability is determined via calculation of net withdrawals (total withdrawals minus returns) which are then compared to how much water can be removed from the stream without creating unacceptable ecological impacts. Understanding how much water can be withdrawn without damaging aquatic ecosystems for each watershed in the state would require lengthy and expensive field studies. Therefore, a methodology was developed for New Jersey application that relies on available science, flow monitoring, and statistical analysis. This methodology, the Stream Low Flow Margin method (referred to interchangeably as LFM or low flow margin), is used to estimate the amount of water that can be withdrawn sustainably (Domber and others, 2013) for each 11-digit Hydrologic Unit (HUC 11; comprised of one or more closely aligned watersheds). The 2017 Plan was the first statewide application of the LFM approach. The LFM approach is also used in the Highlands Regional Master Plan (adopted in 2008), with modifications to address statutory goals for that region. The LFM is defined as the difference between the median September flow and the 7Q10 flow at the lowest elevation of each drainage basin. September was selected because it is typically the driest month of the year in New Jersey. The 7Q10 flow represents the annual minimum 7-day average flow with a 10% occurrence probability and is frequently used as a low flow statistic. HUC11 subwatersheds (HUC11s) or drainage basins are used as the geographic basis for analysis in this Plan update (Hoffman and Pallis, 2009). There are 151 HUC11s in New Jersey ranging in size from about 2,000 to 90,000 acres. The HUC11 was chosen to balance data and analysis limitations with spatial resolution needs. Using a larger unit, such as a HUC 8 or WMA, could cause impacts of withdrawals on ecosystems to be masked. The HUC11 was

chosen as the appropriate delineation for a statewide screening method with the possibility of analysis at a finer scale where potential ecological detriments are identified, such as a HUC11 that is shown as having large net losses. Examination of the results at a smaller scale can provide a clearer sense of which parts of the larger watershed are more or less stressed, and why. The Highlands Regional Master Plan, which is focused on a smaller region, uses HUC14 subwatersheds as a smaller area of focus. DEP anticipates adjusting the LFM method to analyze availability by HUC12, to improve alignment with more recent national work on drainage area and watershed delineations. This would allow for analysis at a finer scale as there are 275 HUC12s within the New Jersey state border compared to 151 HUC11s.

The larger portion of the low flow margin (the difference between the September median and 7Q10 flow) is reserved to support aquatic ecosystems within the HUC11. The remainder is available for routine human use that is not returned to the same watershed (e.g., consumptive and depletive water losses). This Plan uses 25% of the LFM as a planning threshold of excessive depletive and consumptive water loss, with the remaining 75% for ecological maintenance and provision for downstream flows. If there is more net water loss than this threshold, a HUC11 is considered to have limited additional supplies, at least at a preliminary level. In these areas, further analysis is warranted. The hydrogeologic setting of any particular HUC11 is complicated and site-specific analysis is typically required to determine whether a diversion is sustainable or not, through the permitting or planning processes or both. Chapter 4 provides more detailed information on how the results are used in planning. In addition, the LFM results are used within the water allocation regulatory process as one of multiple considerations in whether new or increased allocations should be approved.

A fundamental assumption of the LFM approach is that the same planning threshold is appropriate for all waters outside of the Highlands region, which has special statutory authorities and expectations to protect sensitive aquatic ecosystems. Since adoption of the 2017 Plan, DEP has conducted additional research to update the streamflow database used to derive the LFM and has recalibrated the LFM approach. The results of these analyses are used in this version of the Plan, based on the LFM approach with a 25% planning threshold. DEP compared results of the LFM approach at 25% to another approach, the New Jersey Hydroecologic Alteration Tool (NJHAT, modeling software for determining Ecological Limits of Hydrological Alteration, or ELOHA, Poff et al., 2009), for multiple watersheds across the state in a range of hydrogeologic settings that had sufficient data for the NJHAT analysis (Domber et al., 2013); DEP concluded that generally the LFM approach at 25% would protect ecosystems from excessive withdrawals at the HUC11 level (i.e., not including potential site-specific impacts from withdrawals). The reanalysis confirmed use of the 25% threshold (see Table 2.3) and did not result in major changes to the LFM approach. Therefore, this Plan relies on the use of the 25% planning threshold with additional constraints in situations where the results would reduce flows to surface water supply reservoir systems, imply withdrawals exceeding the 7Q10 flows, and other factors. These additional constraints are intended to avoid flow reductions that would put water supplies and aquatic ecosystems at risk.

Table 2.3 Calibration of the stream low flow margin method using NJHAT

ID	Gage Number	Name	Baseline Period	Drainage Area (mi2)	Stream Type Classification	Stream Flow Reduction (CFS)	Stream Flow Reduction (mgd)	* September Median (mgd)	* 7Q10 (mgd)	Stream Stat Violation	LFM Difference of 7Q10 and September Median (mgd)	** Percent of LFM
1	01464000	Assunpink Creek @ Trenton	1923-1956	91	A	3.891	2.51	26.5	7.97	DL4	18.53	14%
2	01410150	East Branch Bass River near New Gretna	1978-2005	8.11	D	0.581	0.38	7.11	4.17	DL4	2.94	13%
3	01440000	Flatbrook near Flatbrookville	1923-2005	64	A	4.9	3.17	13.57	4.75	ML6	8.82	36%
4	01411000	Great Egg Harbor River @ Folsom	1925-1970	57.1	B	5.5	3.55	28.44	14.01	FH10/DL1	14.43	25%
5	01408000	Manasquan River @ Squankum	1931-1956	44	A	3.5	2.26	21.97	10.83	ML8	11.14	20%
6	01409400	Mullica River near Batsto	1957-2005	46.7	B	6	3.88	25.85	9.39	ML4	16.46	24%
7	01457000	Musconetcong River near Bloomsbury	1921-1972	141	B	9	5.82	67.86	29.57	DL1	38.29	15%
8	01379000	Passaic River near Millington	1921-1979	55.4	A	2.5	1.62	9.51	1.81	ML5	7.7	21%
9	01443500	Paulins Kill @ Blairstown	1921-1975	126	A	11.5	7.43	34.9	10.59	ML7	24.31	31%
10	01477120	Racoon Creek near Swedesboro	1966-2005	26.9	C	2	1.29	10.99	4.75	ML4/ML6/ML8	6.24	21%
11	01384500	Ringwood Creek near Wanaque	1934-1978	19.1	C	0.85	0.55	2.13	0.24	ML5	1.89	29%
12	01380450	Rockaway River @ Main Street @ Boonton	1937-1959	116	A	14	9.05	38.78	9.61	ML6	29.17	31%
13	01465850	South Branch Rancocas Creek @ Vincentown	1961-1975	64.5	B	3.6	2.33	19.35	5.75	DL1	13.6	17%
14	01396500	South Branch Raritan River near High Bridge	1918-1970	65.3	A	4.5	2.91	29.73	14.24	ML4	15.49	19%
15	01408500	Toms River near Toms River	1928-1963	123	B	8.5	5.49	73.68	42.93	DL1	30.75	18%

16	01411300	Tuckahoe River @ Head of River	1969-2005	30.8	C	1	0.65	10.99	4.65	ML5	6.34	10%
17	01409280	Westecunk Creek @ Stafford Forge	1979-1988	15.8	D	3.5	2.26	14.28	8.67	ML8/FH3	5.61	40%
18	01381500	(1) Whippany River @ Morristown	1921-1952	29.4	C	2.5	1.62			ML4	5.153	31%
19	01398000	Neshanic River @ Reaville	1930-1962	25.7	A	0.3	0.19	1.55	0.12	ML6	1.43	14%
20	01409500	Batsto River @ Batsto	1927-2005	67.8	B	9.5	6.14	43.95	26.14	ML9	17.81	34%
21	01467000	N. Branch Rancocas near Pemberton	1921-2005	118	B	10	6.46	53	22.3	ML3	30.7	21%
22	01399500	(2) Lamington River near Pottersville	1921-1950	32.8	C	2.875	1.86			ML4	7.7	24%
23	01396660	(3) Mulhockaway Creek @ Van Syckel	1977-2005	11.8	C	0.6	0.39			ML7	1.9	20%
24	01386000	West Brook near Wanaque	1934-1978	11.8	C	0.45	0.29	1.94	0.38	ML6/FL1	1.56	19%
											Average =	**23%**

(1)- From area ratio of Whippany River HUC11 02030103020 LFM Analysis (69.9 mi2 and 12.2 LFM)
(2) - From area ratio of downstream gage 01399780 flow stats (99 mi2 and 23.2 LFM)
(3) - From area ratio of downstream gage 01396700 flow stats (20.5 mi2 and 3.26 LFM) DL1: Annual minimum daily flow. (cfs)
DL4: Annual Minimum of 30-day moving average flow. (cfs)
ML3: Mean or median (user choice) of March of minimum flow values. Determine the minimum flow for each March over the entire flow record. (cfs) ML4: Mean or median (user choice) of April of minimum flow values. Determine the minimum flow for each April over the entire flow record. (cfs) ML5: Mean or median (user choice) of May of minimum flow values. Determine the minimum flow for each May over the entire flow record. (cfs) ML6: Mean or median (user choice) of June of minimum flow values. Determine the minimum flow for each June over the entire flow record. (cfs) ML7: Mean or median (user choice) of July of minimum flow values. Determine the minimum flow for each July over the entire flow record. (cfs)
ML8: Mean or median (user choice) of August of minimum flow values. Determine the minimum flow for each August over the entire flow record. (cfs)
ML9: Mean or median (user choice) of September of minimum flow values. Determine the minimum flow for each September over the entire flow record. (cfs) FH3: High Flood pulse count. (number of days/year)
FH10: Flood frequency. (number of events/year) FL1: Low flood pulse count. (number of events/year)
*September Median and 7Q10 Flows were obtained from New Jersey Geological Survey Technical Memorandum 13-3, Domber, S., Snook, I., Hoffman, J.L., 2013, "Using the Stream Low Flow Margin Method to Assess Water
**The "Percentages" column is the Stream Flow Reduction divided by the "Difference of 7Q10 and September Median".

Figure 2.4 shows the estimated amount of water available for consumptive and depletive water uses from the unconfined aquifer and surface water system of each HUC11 (in mgd). This does not include the estimate of surface water reservoir safe yields or yields from confined aquifers.

After documentation of the stream low flow margin method in the New Jersey Geological and Water Survey (NJGWS) Technical Memorandum 13-3 (TM13-3) and initial implementation in the 2017 Plan, efforts were made to explore whether adjustments to the method were necessary. NJGWS contracted USGS to perform a recent flow trends study to inform possible changes. Stream statistics, including but not limited to 7Q10 low flows and September median flows, were compared between two time periods: 1950-1979 and 1990-2019. Results of the study were mixed, with only the September median flow statistic displaying a significant difference on a statewide basis. A general increase, though not always statistically significant, in flow statistics was observed at many of the study sites in northern New Jersey, while results in the south were a mix of both increases and decreases. It is possible that these changes in streamflow are related to the changing climate, a topic which is covered in detail in Chapter 3 of this document. Further research is needed to address recent flow trends and climate change as it relates to the method.

It was determined that several modifications to the low flow margin method were needed to more accurately reflect the complex hydrogeologic and hydrologic relationships that exist within a drainage basin, and to better identify regions that may be experiencing hydrologic stresses and require further investigation or action by the DEP. Those changes are outlined below. Unless specifically noted, the method components are the same as defined in TM13-3.

- Water use data period:
  - Water use data through 2020 was used. The last Plan update used data from 2000-2015.
  - 2011-2020 was used to determine peak use due to general statewide stabilization of trends in water use over that period.
- Peak use representation:
  - Peak use will be selected from the three-year period with the highest average net water loss from 2011-2020. Previous Plan updates used the single year with highest loss.
  - The change is designed to reflect the complexity of unconfined groundwater storage and corresponding base flows, as a single year may not accurately represent current peak use conditions.
- Saline discharges:
  - Saline discharges will no longer be incorporated into remaining available water calculations since it requires significant investment before it can be reused. Volumes are still tracked in the summary data tables.
- Additional considerations:
  - Upstream stressed HUC- Highlights any HUC11 that is downstream of another that has been identified as stressed.
  - In a stressed WMA- Net loss was subtracted from total availability for each WMA in the same manner that is carried out on a HUC11-by-HUC11 basis. If a WMA is identified as stressed, all HUC11s within are flagged for a potential availability limitation.

DEP is considering further model improvements to ensure that the results accurately reflect in-situ ecologic/aquatic observed conditions. Additionally, it is also open to consideration of alternative approaches that come from relevant research either in New Jersey or elsewhere. The LFM approach improvements under consideration are:

- application of the New Jersey Hydrologic Alteration Tool (i.e., ELOHA model) to additional sites and updates of previously studied sites using new data and projections that incorporate climate change impacts;
- shifting from analysis at the HUC11 watershed level to the HUC12 subwatershed level; and
- consideration of climate change impacts on water availability.

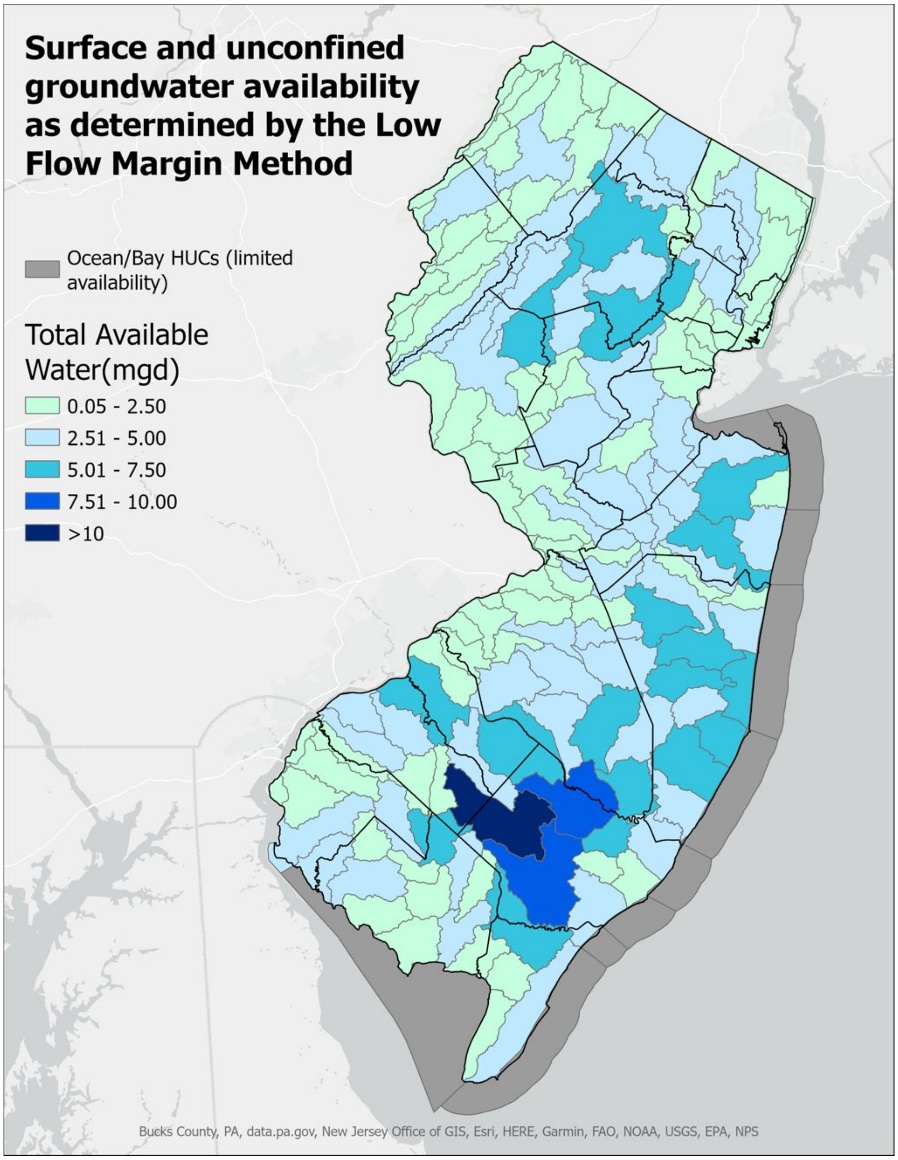

Figure 2.4 Map showing total unconfined groundwater and surface water, excluding reservoirs, available for depletive and consumptive use by HUC11, in millions of gallons per day (mgd). Availability is calculated using the LFM method described in the section above.

CONFINED AQUIFERS

In New Jersey confined aquifers underlie much of New Jersey's Coastal Plain. These aquifers are separated from unconfined aquifers and each other (except where they intersect with the surface in their recharge areas, called outcrop areas) by one or more geologic units that hinder the vertical movement of water (Figure 2.5). Withdrawals from them do not have an immediate effect on the unconfined aquifers and surface waters above them. Groundwater modeling indicates that confined aquifer pumping can increase the amount of water leaving the watershed where the confined aquifer outcrops and becomes unconfined. This is referred to as leakage. For this reason, leakage to and from the confined aquifer is a factor accounted in the low flow margin (LFM) method discussed above.

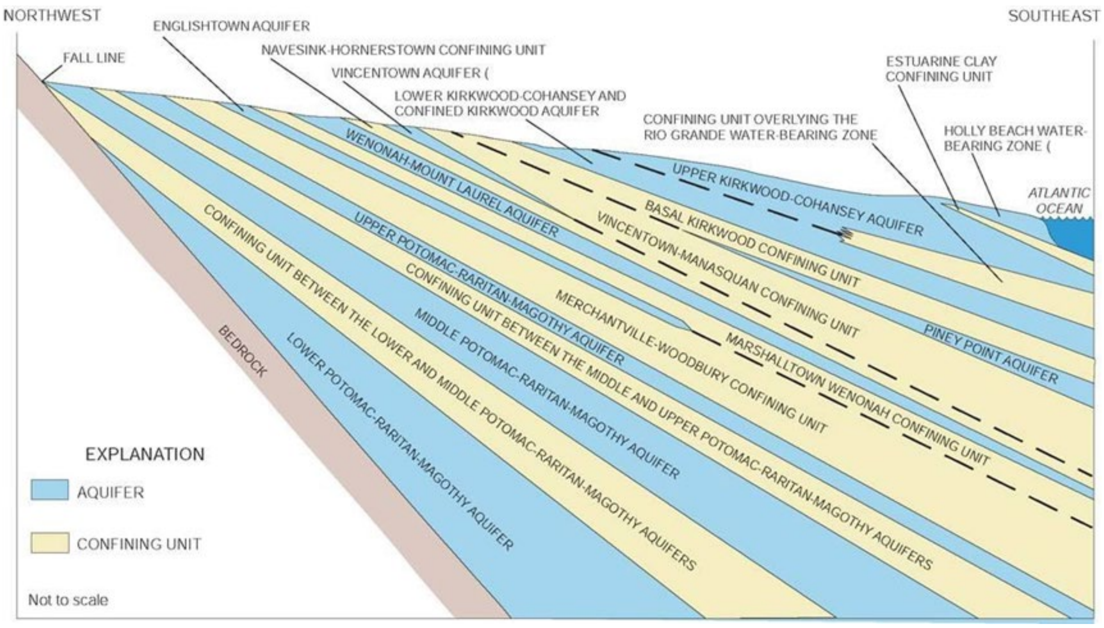

Figure 2.5 Generalized Cross Section of New Jersey's Coastal Plain Aquifer System (from Charles et al., 2011).

Confined aquifers can also experience leakage to and from overlying and underlying confined aquifers, based on differences in the water pressure within each aquifer. These leakages are important factors in confined aquifer models. Confined aquifers also can interact with saline waters along the coastal areas, such that excessive pumping of the confined aquifer can induce saltwater intrusion toward the wells. The focus of this Plan, as with prior plans, is on the major coastal confined aquifers. Some confined aquifers exist in non-coastal areas, but they tend to be geographically limited and closely related to surrounding unconfined aquifers.

Confined aquifers are a significant water supply source for southern New Jersey, providing the majority of potable water supplies to users in the State's coastal plain. Steadily increasing use of these aquifers has caused progressive declines in water levels in some areas and saltwater intrusion in others. Hydrogeologic analysis of the Coastal Plain confined aquifer systems has revealed the interconnected nature of the individual aquifers and their eventual hydraulic connection to water table systems. Due to this interrelationship, new diversions from most confined aquifers draw water from an overlying or underlying aquifer and/or the water table system. This emphasizes the need for a comprehensive, regional water supply planning perspective in assessing the potential impacts of developing additional supplies.

DEP and USGS have conducted cooperative research to upgrade and update the confined aquifer models. Based on this research, USGS provided water balances for each confined aquifer, with consideration of recharge from outcrop areas, movement across the confining layers to and from the confined aquifer, water withdrawals from the aquifer and three scenarios for future demands from existing wells, two based on scenarios from Van Abs et al. (2018) and one using full water allocations; the last is considered a "maximum stress" test that is unlikely to be realized in the foreseeable future. The results are detailed in Appendix C.

WATER AVAILABILITY UNCERTAINTIES

No method of water availability analysis is perfect. The purpose of the Plan is to understand water availability to a level that allows for effective planning and management of water resources. The DEP continues to learn and improve its methods to ensure policy is based on the best available and most up to date scientific understanding of water resource issues. This will, in turn, lead to a more rigorous research agenda regarding specific water resources that are stressed, appear to be stressed, or are critical resources and warrant better baseline knowledge.

Several areas of potential uncertainty exist that are acknowledged here but are considered within acceptable levels for planning purposes. Further research will help reduce these uncertainties over time, for later inclusion in the planning process.

1. Monitoring versus modeling: Modeling is a critical analytical tool that uses available data and knowledge of system processes to estimate current conditions and project future changes. All models are simplifications of reality and are heavily dependent on available data. New Jersey has a robust water monitoring network and is one of the most well developed in the nation, but even so there are data gaps that must be acknowledged. Additional stream flow and aquifer level monitoring stations and an increased knowledge of geology in specific areas would improve model development.
2. Changes in climate conditions: Though there is a good understanding of overall climate change impacts, the specific seasonal and annual variability is still uncertain as well as longer term conditions (i.e., beyond 2050) conditions. Planning can incorporate this uncertainty through the use of risk analysis. For example, if no significant water availability stresses occur under a suite of probable scenarios, then any uncertainty is manageable. If, on the other hand, a major increase in stress is possible under a scenario that has a significant chance of occurring, the planning should incorporate and address that risk. Research results to date are discussed in Chapter 3. Real time or quasi-real time monitoring and periodic reassessments are key activities that can decrease uncertainty and ensure that the DEP has adequate time to address emerging issues.
3. Hydrologic modifications: In a similar vein, it is well understood that water resource infrastructure development and alterations may affect hydrologic systems (e.g., beneficial reuse of treated wastewater, water supply interconnections). Land development and redevelopment will affect demands. However, the specific locations and impacts of these changes over the next 30 years or more cannot be specified at this time. New Jersey is currently updating its Statewide Development and Redevelopment Plan and future WSPs will utilize the State Plan resources available. As with climate change, the use of scenarios is the best approach for determining whether potential modifications of hydrologic conditions and water demands pose significant risk.
4. Local natural resource limitation and or permit conditions on regional resources: The analysis used in this Plan is based on large-scale planning units, such as confined aquifers, reservoir systems and HUC11s. The water availability results for the confined and unconfined aquifers may not reflect local limitations on withdrawals. Where water is withdrawn is important. For example, the same volume of confined aquifer withdrawal will have different impacts depending on whether the well is close to or distant from saline water. Reservoir safe yields can change based on downstream flow requirements. Unconfined aquifer withdrawals may be restricted due to wetlands protection, effects on nearby wells, etc. Therefore, what is available regionally may not be available where it is needed locally. In situations where regional studies indicate stresses, local supplies may be available depending on specifics of the request. In these cases, additional modeling, assessment, and studies may be required to confirm that the local supply is sustainable and will not exacerbate the regional issue.
5. Regional and watershed/aquifer water availability interactions: One of the more difficult analytical issues is that the three major categories of water availability (reservoir systems, unconfined aquifers, confined aquifers) interact. Reservoirs rely heavily on groundwater discharges to streams that flow into the reservoirs, and therefore the safe yields can be reduced by upstream aquifer withdrawals. As noted in the confined aquifer discussions, the overlying unconfined aquifers can be a source of recharge to the confined aquifer, or vice versa, depending on local conditions. These natural and induced inter-flows are important to modeling, which is best performed for specific regions where there is a current or future concern.
6. Infrastructure-related inter-flows: Water transfers through water and wastewater infrastructure are tracked in the various water availability models to the extent possible. These transfers may occur

between HUC11s (e.g., upstream to downstream, downstream to upstream, between unconnected river basins), from fresh-water resources to ocean wastewater discharges, and through Managed Aquifer Recovery systems. Beneficial reuse of treated wastewater, either directly or indirectly, can alter water availability calculations as well. As one interesting example of water transfers, New Jersey American Water constructed a finished water pipeline that transfers water from the Passaic Valley Water Commission (PVWC) up basin to the Morristown and Millburn areas of Morris and Union Counties. After use of this water by the consumers, the resultant wastewater is treated and discharged back into the river where it is available for other downstream users, including the PVWC facility. Much of the flow in the lower Passaic River during low flow periods is supplied by treated sanitary wastewater discharges.

7. Interstate flow requirements: New Jersey contributes flow to New York State (Wallkill River) and receives flow from New York (Hackensack, Wanaque and Ramapo Rivers). There are expectations of flows that are established by regulation in the two states but are not subject to formal agreements. While the Wallkill River does not contribute to a reservoir safe yield in New York, the three incoming rivers do support safe yields in the Hackensack system (Veolia) and the Wanaque System (North Jersey District Water Supply Commission). New Jersey is also a party to the Delaware River Basin Supreme Court decision, which ensures that water withdrawals and releases from the Catskill-Delaware reservoirs of New York City and other water withdrawals in the four basin states (Delaware, New Jersey, New York and Pennsylvania) do not exceed available supplies. The five parties (the four states and New York City) periodically negotiate modifications to the agreement, which can in turn modify water availability for New Jersey.
8. Water quality constraints on supply: Historic water quality problems have forced public community water systems to abandon supplies, such as Newark's decision to stop using the Passaic River locally around the turn of the 20th century, and build reservoir systems in the Pequannock watershed. Other urban areas did likewise. In the 1980s, recognition and establishment of water quality criteria for volatile organic chemicals (VOCs) and other industrial contaminants resulted in advanced treatment of some wells, but also in the abandonment of other wells due to decisions that the use of alternative supplies was preferable than use of the existing supply, due to concerns about either treatment viability or excessive costs. This issue was assessed in the 1996 Plan. Currently, new maximum contaminant levels (MCLs) for several PFAS chemicals and anticipated MCLs for other compounds will likely force consideration of treatment viability and costs relative to the abandonment of supplies and use of alternatives. While the contaminated resources will still exist and may in the future be usable if cost-effective treatment becomes available, abandonment of these supplies could represent a local reduction in water availability. The next section summarizes ongoing research on these issues.

All of these considerations create some uncertainty in water availability calculations that must be addressed in the planning process.

POTENTIAL WATER LOSSES TO CONTAMINATION

The sections above discuss water supply availability from a quantity perspective, which has been the typical focus of earlier water supply plans in New Jersey. The connection between supply and quality has always been made, but this Plan broadens those links and addresses specific water quality issues- especially those impacting drinking water. Water is only truly available if it is available in the necessary volumes and of the appropriate quality. While effective water treatment technologies exist which ensure water meets the necessary health standards for its intended use, there are limits including time requirements to design and build new technologies; very real cost constraints to install, operate and maintain those treatment processes; and space/land use limitations for some water systems. The state is currently experiencing challenges as water utilities are required to comply with the existing New Jersey MCL standards for three PFAS contaminants, while reacting to the proposed EPA MCLs which are much lower than the current New Jersey MCL standards. The lower and expanded federal standards recently

proposed for this suite of chemicals are anticipated to impact more water systems statewide and exacerbate the challenges New Jersey is already experiencing.

To further expand the scope of this Plan, the following section uses the existing (but ultimately limited) safe drinking water quality data to evaluate the distribution of PFAS throughout the state and quantifies the potential threat on unused but available drinking water supplies from PFAS or other contaminants. An overview of the already significant amount of treatment the state's water utilities are already implementing is covered in Chapter 5. While this section focuses on PFAS, the overall issue of new MCLs or emerging contaminants has the potential to have similar impacts to water supplies and cost of water. For example, increasing trends in chlorides, primarily from road salt applications, have been noted and are a concern due to the extreme difficulty and cost of removing it. 1,4 dioxane and cyanotoxins are other examples.

STATEWIDE PFAS WATER SUPPLY ANALYSIS

Per- and polyfluoroalkyl substances (PFAS), including perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), and perfluorononanoic acid (PFNA), have been regulated in New Jersey's drinking water via a maximum contaminant level (MCL) since 2018 for PFNA and 2020 for PFOA and PFOS. The unique substances that fall under the PFAS umbrella can be referred to as analytes.

On certain occasions, the discovery that a public water system's finished water violates the MCL for PFAS has resulted in at least a temporary loss of water supply while installing new or updating existing treatment technology. In these cases, systems may choose to switch to alternate water sources, including purchased water from neighboring purveyors. This presents a concern that certain systems or water sources may face increasing demands on a temporary or permanent basis due to loss of supply in affected systems found to violate newly adopted water quality standards.

To explore the problem from a water supply planning perspective, NJGWS performed an analysis of statewide reported PFAS sample results to highlight regions or sources of water where levels have been elevated. It is important to note that the maps and charts that follow include, in addition to more recent data, PFAS sample data that was collected prior to the introduction of the New Jersey MCL and in some cases, prior to the installation of treatment. "Hot spots" on the maps do not represent water systems that are in violation of PFAS MCLs, but instead highlight areas with elevated density of PFAS samples of higher concentrations. Additionally, risk analysis was conducted to show how systems that rely on surface water sources could be stressed by demands associated with neighboring systems responding to PFAS MCL violations, which tend to have a greater impact to groundwater sources, and requiring purchased water to replace sources.

The DEP chose to explore the impacts of PFAS on water supply due to their presence as a relatively new threat and the availability of sample data. However, there are other emerging contaminants, such as 1,4-dioxane, that may have similar impacts on supply.

Figures 2.6 and 2.7 are heat maps developed from singular PFAS sample detection data that was submitted to the Bureau of Safe Drinking Water for required monitoring purposes from 2019 to 2022. While samples were collected before 2019, and for a portion of 2023 when this chapter was drafted, these years were selected due to the significant number of data points and their geographic spread. The data are point-of-entry samples, collected after raw water traveled through the existing drinking water treatment processes. While not ideal data, as some systems may have had existing treatment for other reasons which also removed PFAS, this is the best statewide potable water dataset available to the DEP. It should be noted that a single sample result in excess of an MCL does not denote a violation by the water system (which is determined based on a running annual average). Note that the concept of a heat map has multiple uses and the concept discussed in this Plan is not related to temperature.

A heat map is a depiction of the relative density of plotted points. In this case, the points represent PFAS samples, and a weight is applied via the analyte concentration so that samples with higher concentrations have a greater

effect on the occurrence density pictured in the maps. These maps were produced using ESRI's heat map symbology which relies upon the kernel density method, described in detail by Silverman (1986). For each point, a surface is produced with the highest value at the location of the point and decreasing values at increasing distance from said point, eventually reaching zero at the search radius selected by the user. The weighting field, which in this case is sample concentration, is the number of times the value is counted for the surface associated with each point. Surfaces overlap where points are located near one another, and the values of the overlapping surfaces are summed. The result is the occurrence density, symbolized in yellow, orange, and red on the maps. It is important to note that the heat maps and occurrence density areas are NOT representative of in situ water quality PFAS concentrations, but rather show areas where occurrences are more likely. We accept there may very well be other areas not identified in the maps which also have PFAS contamination present, but which were not mapped by this specific process. While other PFAS sample data sets exist, such as the ambient groundwater monitoring network and samples associated with the site remediation program, this analysis was focused on drinking water and therefore relied upon finished water samples. Figure 2.6 organizes sample data by analyte and each individual map includes all samples for the given analyte from 2019 to 2022. There are very few locations where a significant density of high concentration PFNA samples occurs, and there is significant overlap in PFOS and PFOA "hot spots." In Figure 2.7, sample data for different analytes are combined and arranged on a year-to-year basis. Changes over time in the position and intensity of "hot spots" may be caused by water sources going offline, the addition of new treatment processes, or other reasons. Some water systems have stopped using water sources temporarily, added new treatment to eliminate contaminants, and begun to distribute water from those sources again. This could contribute to a reduction in occurrence density of samples with elevated PFAS concentrations.

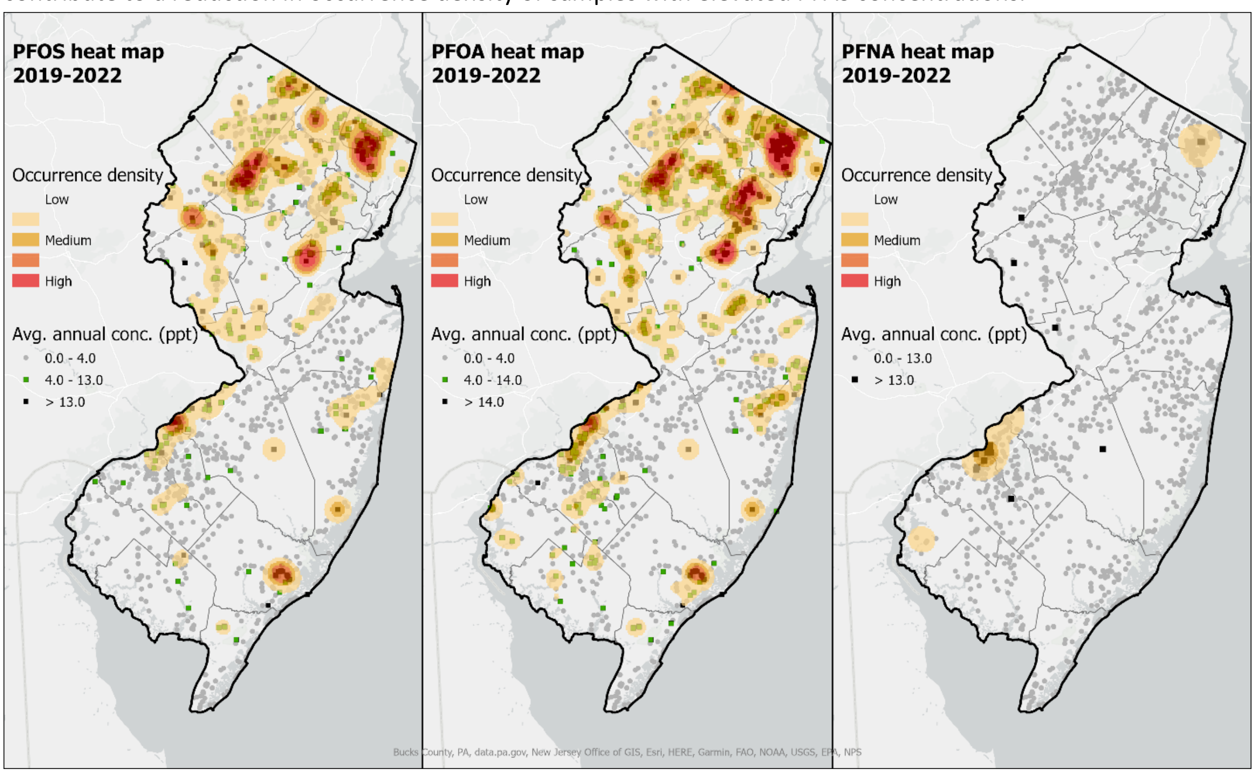

Figure 2.6 Heat maps, developed based on kernel density method with weighting for sample concentration, show the areas where the occurrence of elevated samples has been more or less dense. Sample points are symbolized to highlight the New Jersey MCLs (13 or 14 ng/L or parts per trillion(ppt)) and the proposed EPA MCLs (4 ng/L or ppt). Note: Symbology for sample points is different in the PFNA map because the proposed EPA MCL for PFNA is folded into a Hazard Index for PFAS that is not sampled for in New Jersey.

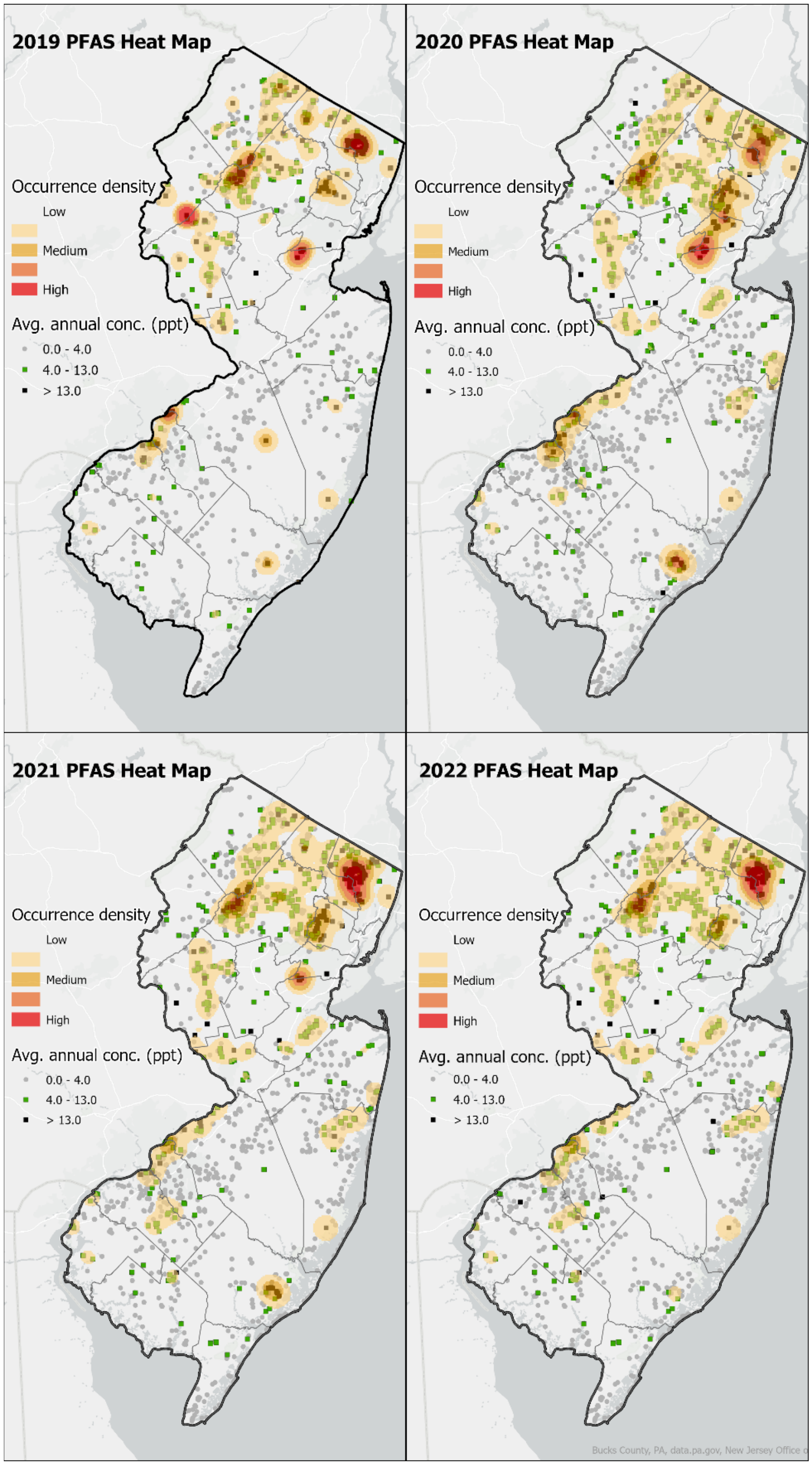

Figure 2.7 Heat maps, developed based on kernel density method with weighting for sample concentration, combining occurrence density for the three PFAS analytes (PFNA, PFOS and PFOA) currently regulated by a New Jersey drinking water MCL, organized by year from 2019-2022. Sample points are symbolized to highlight New

Jersey MCL's for which the 13 ng/L (ppt) value was chosen due to the fact that applies to two out of the three substances. A single EPA MCL of 4 ng/L (applies to PFOA and PFOS) was included in the symbology.

A primary goal of this PFAS analysis was to determine which raw water sources are more likely to be contaminated by these substances. The maps above provide geographic context for statewide PFAS sampling, but do not connect the results to water source. The box and whisker plots that follow display the same sampling data expanded to include all PFAS samples available at the time this chapter was developed, spanning 2013 to 2023.

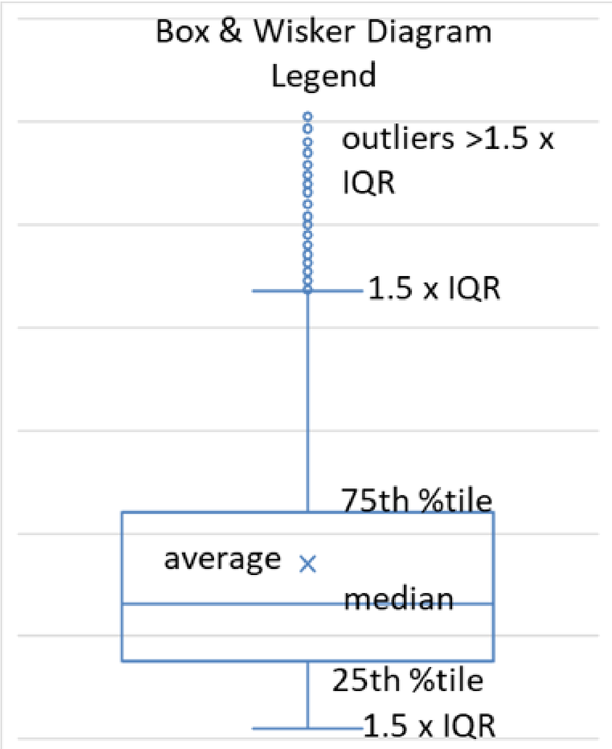

Figure 2.8 Description of box and whisker plots displayed in following figures. IQR refers to the interquartile range, represented by the box which includes data points for the middle two quartiles.

Figure 2.8 shows the components of a box and whisker plot. The box area represents the spread of values between the 25^{th} and 75^{th} percentiles, also known as the interquartile range (IQR). Within the IQR, the central line is the median and the X represents the average value. The "whiskers" extend to 1.5 multiplied by the IQR, beyond which all values are identified as outliers.

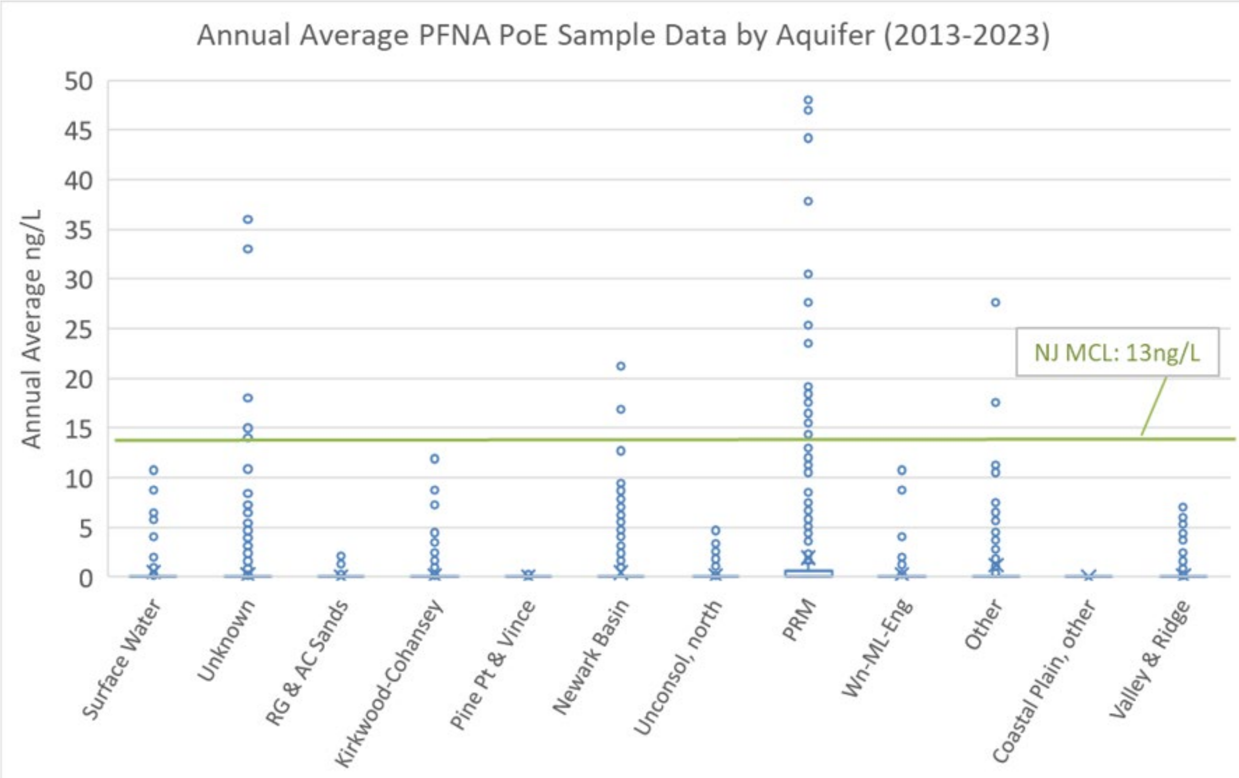

Figure 2.9 Box and whisker plot showing PFNA sample results, organized by aquifer. The green line represents the New Jersey MCL for PFNA which became effective in 2019.

Relatively few samples exceed the New Jersey MCL (13 ng/L) for PFNA, which is shown in Figure 2.9. The boxes for the water resources are barely visible because the IQR for each is very close to zero. The IQR and average value for samples taken from PRM water sources stand out but do not approach the New Jersey MCL, although a number of outlier samples exceed it. While these are noted as statistical outliers on a box and whisker plot, they are treated no differently than other sample results in the process of evaluating water quality.

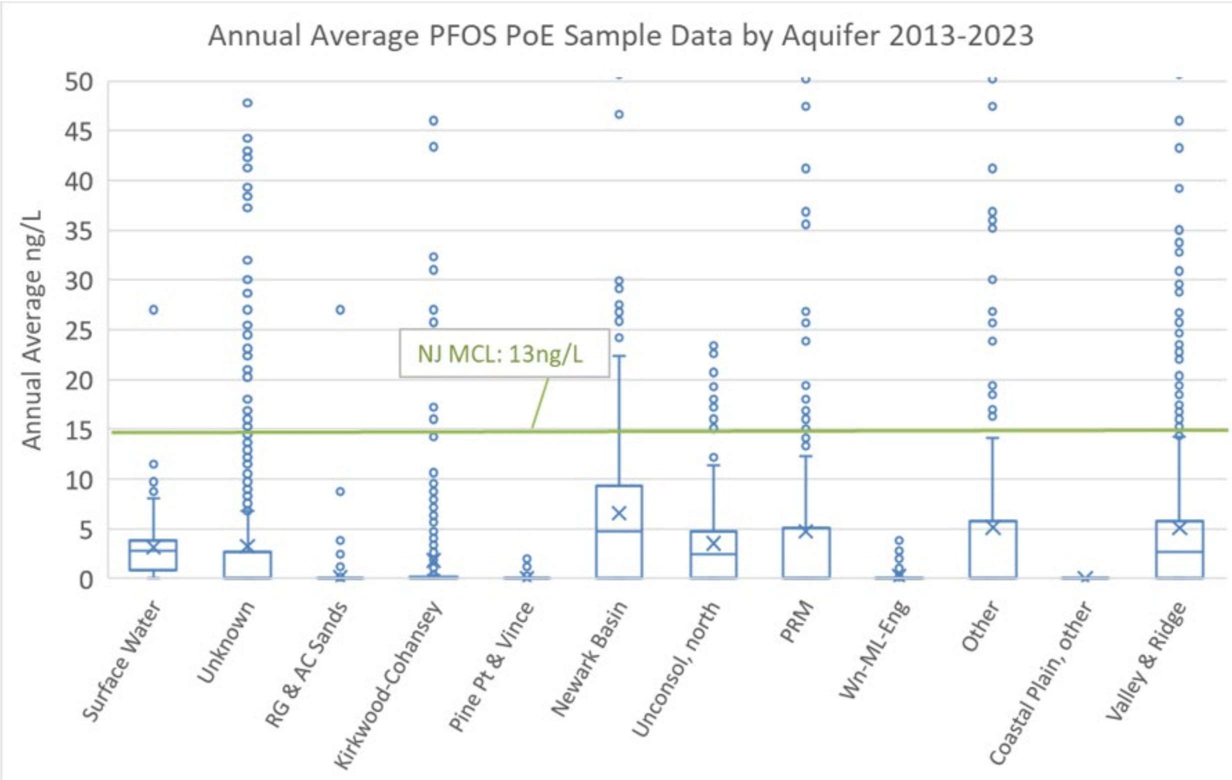

Figure 2.10 Box and whisker plot showing PFOS sample results, organized by aquifer. The green line represents the New Jersey MCL for PFOS which became effective in 2020.

When compared to the previous box and whisker plot for PFNA, Figure 2.10 displays a relatively more significant presence of PFOS. However, only the Newark Basin sampling data shows an upper boundary above the New Jersey MCL and none of the water resources' IQRs reaches that threshold. The 75th percentile of sample data for the unconsolidated aquifers in northern New Jersey, the PRM aquifer and the Valley and Ridge aquifer system reaches or just exceeds 5 ng/L. This is relevant due to the proposed EPA MCL for PFOS of 4 ng/L. A number of samples pictured as outliers exceed the New Jersey MCL.

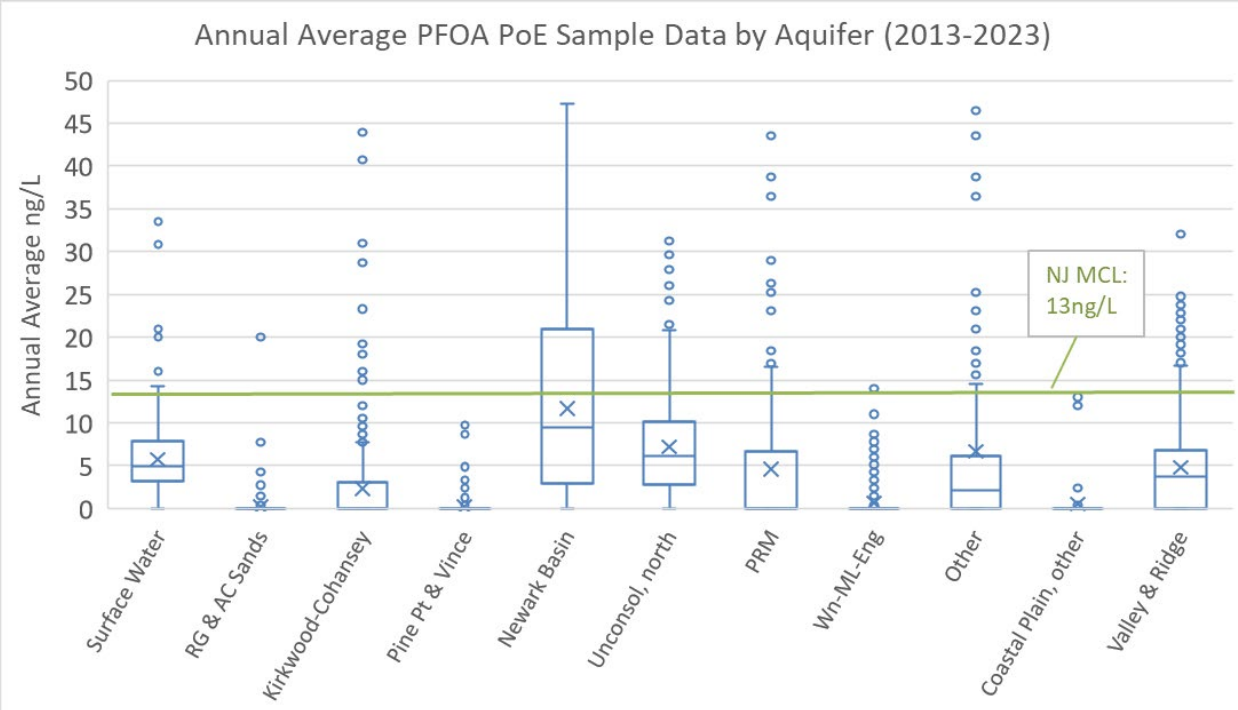

Figure 2.11 Box and whisker plot showing PFOA sample results, organized by aquifer. The green line represents the New Jersey MCL for PFOA which became effective in 2020.

Figure 2.11 shows that, for most water resources, samples for PFOA are returning higher concentrations than the other two analytes. A significant amount of the IQR for Newark Basin samples is above the New Jersey MCL and the associated median and average are close to the threshold. IQRs for the unconsolidated aquifers in northern New Jersey, the PRM aquifer, and the Valley and Ridge aquifer system are higher than for PFOS. Surface water samples display higher concentrations than for PFOS or PFNA and the median and average for these are above the proposed EPA MCL of 4 ng/L. Average sample concentrations for the Newark Basin, the unconsolidated aquifers in northern New Jersey, the PRM aquifer, and the Valley and Ridge aquifer system are at or above the proposed EPA MCL. For most water resources on the chart, there are fewer points identified as outliers and broader IQRs than for the other analytes, suggesting that sample concentrations are more tightly clustered.

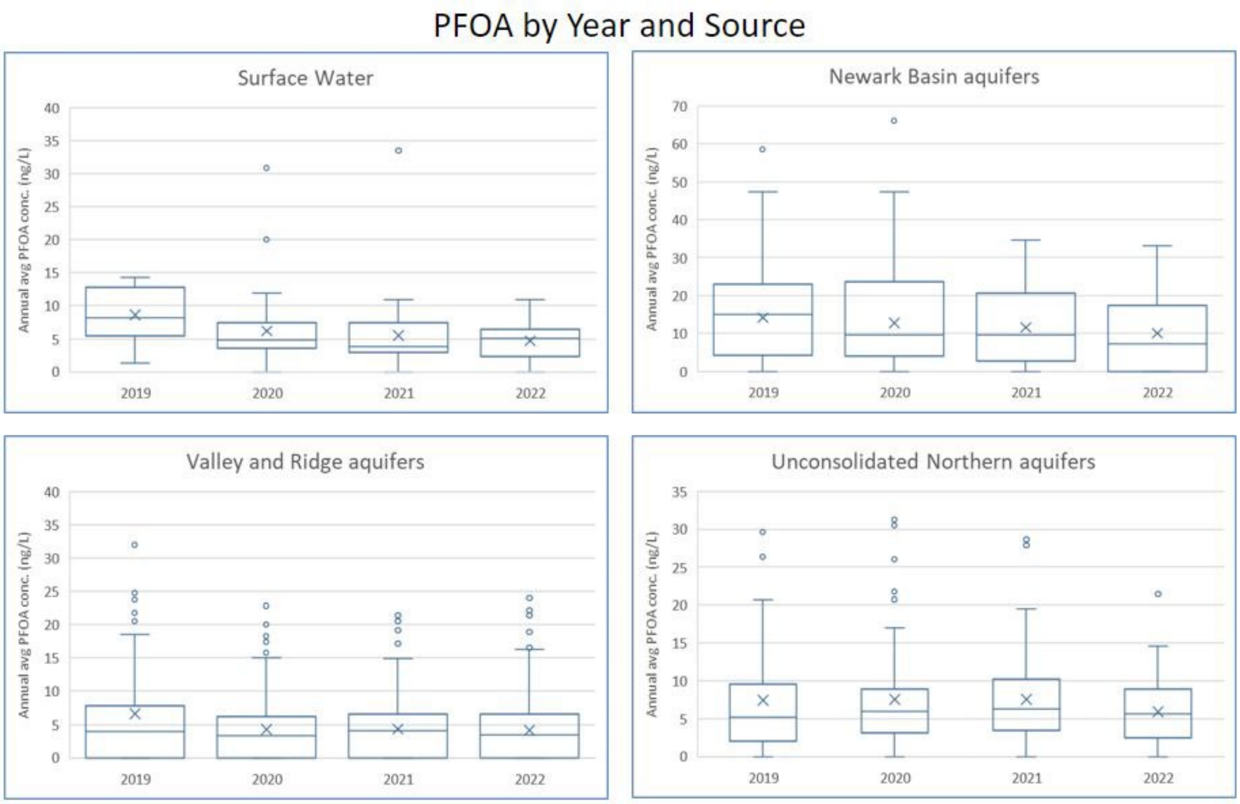

Figure 2.12 Box and whisker plots for PFOA only from 2019-2022, organized by select aquifers.

Figure 2.12 shows the change in PFOA sample concentration over time for four selected water resources. Surface water shows the most noticeable change, with median and average concentration dropping after 2019, and a tightening of the IQR for 2020-2022. The IQR for Newark Basin samples decreases less but the median and mean drop below the New Jersey MCL. Samples from the Valley and Ridge aquifer system and the unconsolidated aquifers in northern New Jersey exhibit minimal change.

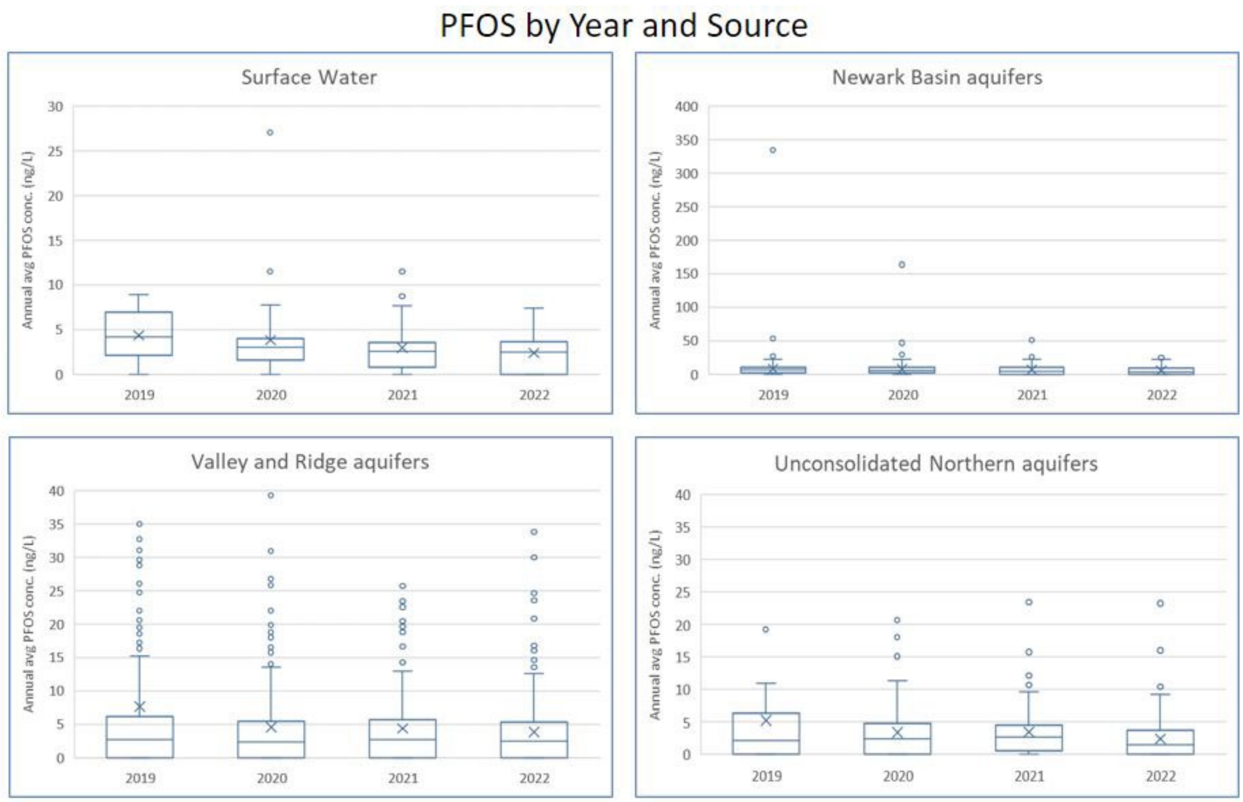

Figure 2.13 Box and whisker plots for PFOS only from 2019-2022, organized by select aquifers.

Overall, PFOS concentrations are lower than PFOA in the selected water resources (Figure 2.13). Surface water samples show a decrease similar to what was observed for PFOA, and by 2020 the entire IQR, median, and average are below 5 ng/L. The box and whisker for samples collected from Newar Basin aquifer sources is skewed by two data points with extremely high concentrations, but IQRs, medians, and average for all four years are below the New Jersey MCL. Concentrations for the unconsolidated aquifers of northern New Jersey decreased from 2020 to 2022 while those for the Valley and Ridge aquifer system remained very stable.

Figures 2.9 to 2.11 show data for the three analytes, PFNA, PFOS, PFOA, binned by water source. It is clear that the presence of PFAS is not uniformly distributed among sources, with some more frequently returning samples at or above the state's MCL. Samples for four highly relevant water sources that returned a significant number of high concentration values were arranged by year and analyte in Figures 2.12 to 2.13. Changes over time may have occurred for a variety of reasons, some of which are mentioned previously in relation to Figure 2.6. The availability of statewide raw water sample data available to the DEP would enhance these analyses.

PCWS VULNERABILITY ASSESSMENT

The impacts of PFAS and other emerging contaminants are still being realized and are ultimately difficult to predict, but temporary or permanent source losses have occurred and will continue to pose challenges for public water systems in the future. To identify water systems where loss of groundwater sources due to contamination could exceed available supplies, the DEP conducted a vulnerability assessment. The assessment method focused on the major surface water systems in New Jersey (who are common, temporary, or permanent "go to" suppliers of water), their interconnected neighbors, and simulated the loss of sources and the increased need for transfers. Unconfined groundwater loss was simulated in percent breaks, to determine the degree of loss that would result in a surface water system exceeding their assigned public water system deficit/surplus estimates as determined by the Division of Water Supply and Geoscience. Assumptions include that the system in question and its neighbors experience unconfined groundwater loss at the same thresholds, and that the surface water system will transfer

water to its neighbors to account for their loss. For the purposes of this assessment, a system's neighbors are defined as systems that are geographically adjacent or that have purchased water from or sold water to the system in question. Demands used were developed for the Surplus/Deficit Analysis completed in January 2023. Systems that would not be able to meet demands in the instance of 100% loss of unconfined groundwater supply are described as potentially vulnerable in Figure 2.14. As deficit/surplus results are periodically updated these results may change and therefore should be periodically updated to identify systems that continue to show vulnerability over multiple reassessments.

Surface water sources can also contain PFAS, HABs or other contaminants which can reduce supplies of the surface water systems, either permanently or temporarily. This analysis only covers the groundwater loss and use of surface water, but it could be expanded to include the loss of any source of water. It is closely linked to the finished water storage waiver issue covered in Chapter 7.

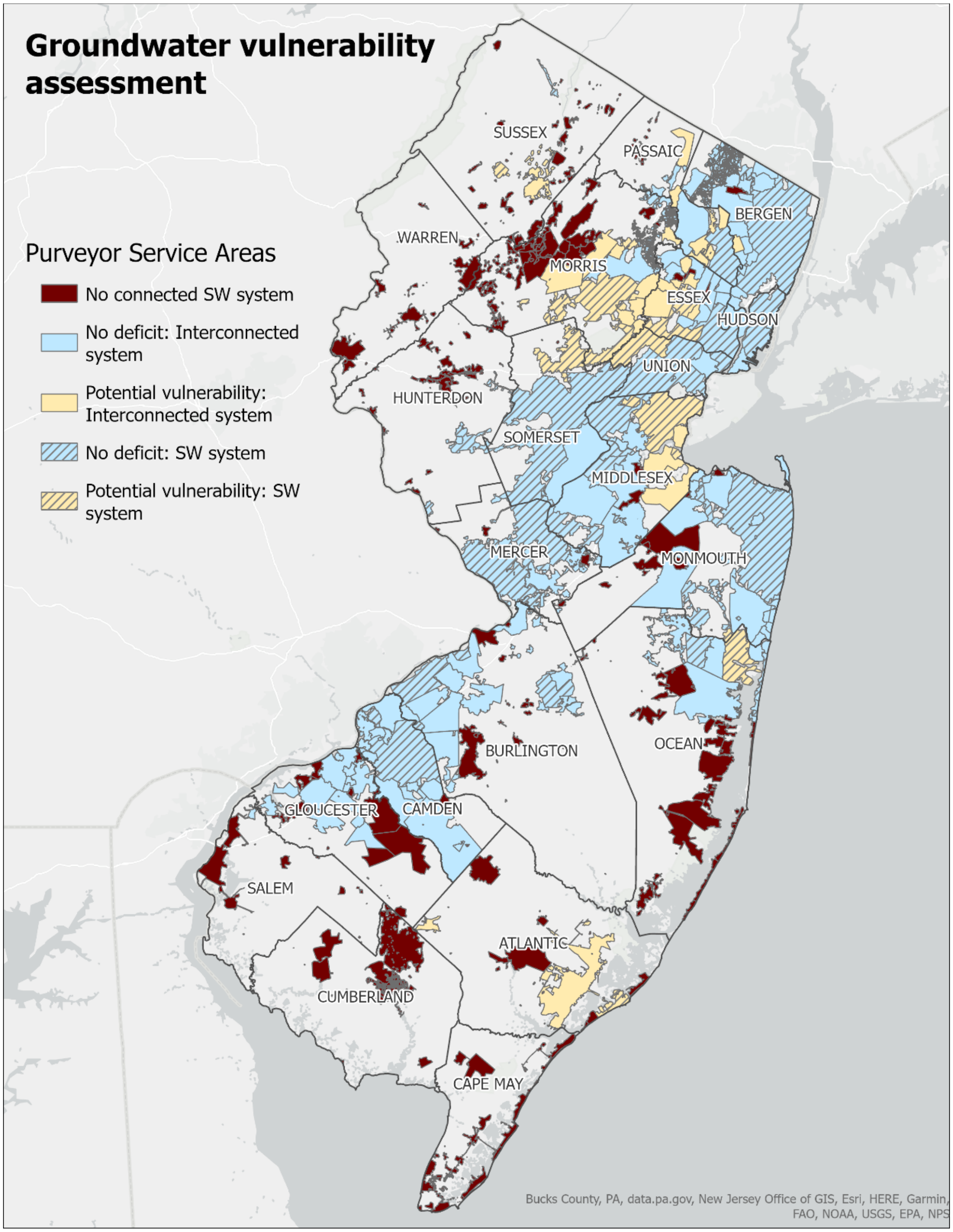

Figure 2.14 Statewide map with systems symbolized based on the groundwater vulnerability assessment. Systems where 100% loss of unconfined groundwater could cause a supply deficit are identified as potentially vulnerable. Major surface water systems are symbolized with cross hatching. Within the legend surface water is abbreviated as SW.

This assessment only simulates loss of unconfined groundwater and the potential impacts on interconnected systems as a response to PFAS-caused supply challenges, but the method could be applied to other water resources. For example, temporary loss of surface water supplies is possible - and has occurred already - as a result

of harmful algal blooms (HABs). A similar vulnerability assessment could be carried out in the future to analyze collective risk related to HABs or other contaminants. Although it is unknown what future issues will be posed by emerging contaminants, water supply vulnerabilities can be explored using this analytical approach.

INFRASTRUCTURE DEVELOPMENT RISKS

Technologies developed to facilitate the installation of infrastructure like Horizontal Direction Drilling (HDD) create opportunities but also present risks if not properly managed and regulated. HDD can allow for utilities to run necessary infrastructure through highly sensitive environments without disturbing the surface areas along the route. While HDD minimizes the percent surface area disturbance and avoids disturbance of highly sensitive environments, the potential effects of Inadvertent Returns (IR) can be consequential. Based on reviews of HDD projects and related studies, HDD activities carry a potential risk to groundwater as well as to surface water supplies through the IR of fugitive drilling muds and fluids which become a source of pollution in groundwater, surface water/sediments, and or the ecologically sensitive area that was intended to be unharmed through this alternate process. Currently New Jersey has no regulatory requirement pertaining to the HDD activities, unlike the N.J.A.C. 7:9D regulations which oversee and regulate the installation of conventional vertical wells. Recent studies (Peters et al., 2014) and documentations of unsuccessful HDD activities show that unintended IRs pose potential risks to groundwater, surface water, and ecological areas. It is recommended that the oversight and proper regulatory management of HDDs throughout the process of planning, construction, installation, and decommissioning should be considered to prevent potential impacts and minimize risks.

SUMMARY

A clear analysis of natural water availability and the built infrastructure necessary for water storage is needed to understand where water supplies are adequate or inadequate to address both current and future demands. This chapter aims to address that need by providing an overview of natural water resource availability and administratively approved availability throughout New Jersey. Although not evenly distributed throughout the state, total natural water resource availability (including reservoirs) is an estimated 1,791 mgd, with surface water reservoir systems, unconfined aquifers and associated streams, and confined aquifers providing 785 mgd, 387 mgd, and 619 mgd, respectively.

Natural vegetation located along the Green Bank Bridge in Mullica Township, Atlantic County. The bridge crosses over the Mullica River, connecting Atlantic and Burlington counties.

DEP relies on the use of both the stream Low Flow Margin method and confined aquifer models to help estimate statewide water availability. Since the 2017 Plan, the DEP made adjustments to the stream Low Flow Margin method to more accurately reflect hydrogeologic and hydrologic relationships and to

better identify regions potentially facing hydrologic stress. Adjustments to this approach included the incorporation of more recent water use data, alterations in how peak use is represented in analysis methods, and the removal of saline discharges from remaining available water calculations. The DEP and USGS have also worked collaboratively to improve the estimation of water availability in confined aquifers by upgrading and updating confined aquifer models to provide water balances for each confined aquifer in the New Jersey Coastal Plain. However, analytical estimations of water availability in confined aquifers – as with estimations of unconfined aquifer and surface water availability – will always have some uncertainty. DEP will continue to work to reduce uncertainty in its approaches to estimate water availability.

This chapter also focused on examining the potential impacts that water quality issues may have on available supply, including an analysis of the threat to drinking water posed by the presence of PFAS. An examination of PFAS sampling results showed that exceedances of current New Jersey MCLs are not uniformly distributed. Some water resources, such as the Newark Basin and the Valley and Ridge aquifers, appear more likely to return a sample with a high concentration of one of the three PFAS analytes- PFNA, PFOS, and PFOA. A PCWS vulnerability assessment was also conducted to identify water systems where a loss of groundwater sources due to contamination could stress available supplies.

While the DEP explored the impacts of PFAS on water supply due to their presence as a relatively new threat, other emerging contaminants, such as 1,4-dioxane, have the potential to have similar impacts on supply. By considering major surface water systems and their interconnections, this chapter identified systems that may be vulnerable if temporary or permanent unconfined groundwater source losses occur in the future due to PFAS-caused supply issues. The DEP is committed to continuing to monitor PFAS and other contaminants that may influence New Jersey water supply availability and improving analyses as statewide raw water sample data becomes more available.

Two specific areas DEP intends to target related to its research approach to estimate statewide water availability include:

- continuing its ongoing research to further refine the Low Flow Margin method by determining: (a) how climate change may influence recent flow trends; and (b) how to more accurately reflect ecologic/aquatic observed conditions in-situ; and
- further evaluation of strategies to reduce uncertainty in water availability estimations based on the use of periodic reassessments, and further research on the geology of specific locations and the use of real time or quasi-real time monitoring.

CHAPTER 3: CLIMATE CHANGE IMPACTS TO WATER AVAILABILITY

TABLE OF CONTENTS

OVERVIEW

The earth is warming and 2023, exacerbated by the onset of El Niño conditions in the Pacific Ocean, was globally the hottest year on record. In 2023, New Jersey has seen its warmest January since at least 1895, while February and April had average temperatures among the five highest for those months over the same time period. To date the state has also experienced multiple weeks of hot and dry conditions ended abruptly by intense precipitation events. This extreme variability appears to be occurring more frequently and is one of the forecasted effects of a changing climate. It is well documented that New Jersey is not immune to the impacts of climate change and is in fact already facing significant direct and indirect consequences, some of which are more severe than those experienced in most other regions of the country and the world. The 2020 New Jersey Scientific Report on Climate Change communicated that sea-levels are rising and temperatures are increasing at a greater rate in New Jersey than other parts of the Northeast region and the world. It also reports that precipitation is increasing, with annual precipitation increasing by 7.9% over the long-term average in the last 10 years alone. Additionally, storm events producing extreme precipitation have increased by 71% over the last 50 years. The 2020 New Jersey Scientific Report on Climate Change found that sea-levels are expected to rise approximately one to two feet by 2050 and two to five feet by 2100; precipitation may increase 4% to 11% by 2050; and temperatures are expected to increase by another 4.1°F to 5.7°F by 2100 (NJDEP, 2020). T

A beach and shorefront community located in Brigantine, New Jersey. Sea level rise poses a risk to critical infrastructure and water resources located in New Jersey's coastal areas.

These climate drivers -- sea-level rise, increasing temperatures, and increasing precipitation -- have direct and indirect impacts to the state's natural and built water supplies and can lead to critical water supply stresses. While more rainfall can result in more streamflow into reservoirs, peak streamflow can stress aquatic and drinking water quality and floods can inundate critical infrastructure. More precipitation can

lead to more groundwater recharge, but warmer temperatures can result in longer growing seasons, and more evapotranspiration and large storm events can result in more runoff (potentially carrying contaminants into surface water) and less groundwater recharge. Warmer temperatures can also increase water demands; including potable, agricultural and power generation. Sea-level rise will force saltwater into unconfined aquifers and estuaries and cause wells and intakes to become salty permanently or periodically during droughts. Climate change is and will continue to be the major driver of water availability issues for the state.

This chapter represents the first major evaluation of climate change implications for water availability and water demand within a Plan. The findings included in this Plan were developed using reliable climate change science and technically sound modeling efforts by the DEP. As the science of climate change impacts on water resources evolves, the DEP will monitor and incorporate new developments. This chapter captures current, well-established knowledge of climate trends and is focused on screening-level-type evaluations. It builds on the climate science and forecasts outlined in the DEP's 2020 Scientific Report on Climate Change and incorporates information from the Rutgers State of the Climate reports and other research. Updates to this Plan will be developed over time and as appropriate. This evaluation is primarily used to identify data gaps and uncertainties, priority topics needing further investigation, and initial assessments of magnitude and severity of impacts to New Jersey's water supplies. This analysis is the start of an ongoing scientific, policy and regulatory process that must continue to use the best available science and modeling techniques.

OVERVIEW OF CLIMATE SCIENCE

As documented by the 2020 New Jersey Scientific Report on Climate Change (NJDEP, 2020), climate change is occurring and will continue to occur. Three major climate change effects which will impact water availability are evaluated in this Plan: temperature change, precipitation change, and sea level rise. Each has the potential to modify water availability and water demands in different ways. The major climate change drivers and potential impacts to New Jersey can be viewed via the Climate Change in New Jersey: Impacts and Effects web product which includes useful maps and graphics.

TEMPERATURE

Increasing temperatures can shift precipitation types (e.g., snowfall to rainfall), increase evapotranspiration rates, increase soil moisture deficits, increase the intensity of storms, and increase and extend water demands. Generally stated, New Jersey temperatures have been rising year-round, but especially in the winter, and faster than the global average.

New Jersey temperatures are increasing faster than the rest of the Northeast, by 3.5°F since 1895, and are projected to increase by 4°F to 10°F through the year 2100 (under moderate and high emission trends, respectively), with winters warming faster than annual averages (Shope et al., 2023). Figure 3.1 shows the five warmest and coolest months (compared to the average) on record from 1895 through 2022, with a clear trend from cooler months in the early 1900s to warmer months in the 21st century.

Global Climate Models (GCM) provide various scenarios for future conditions, depending on greenhouse gas emission trends, and downscaling these models for use in a small state or even the Mid-Atlantic region is an important next step. Shope et al. (2023) note that "this warming trend is expected to accelerate with further climate change". These GCMs are reasonably good at predicting annual average temperatures at a global-regional scale. However, daily, monthly, and seasonal temperature changes can significantly impact water demands and influence drought conditions, so it is critical that modeling capability be expanded and improved to better forecast and plan at state-specific spatial and more finite temporal scales.

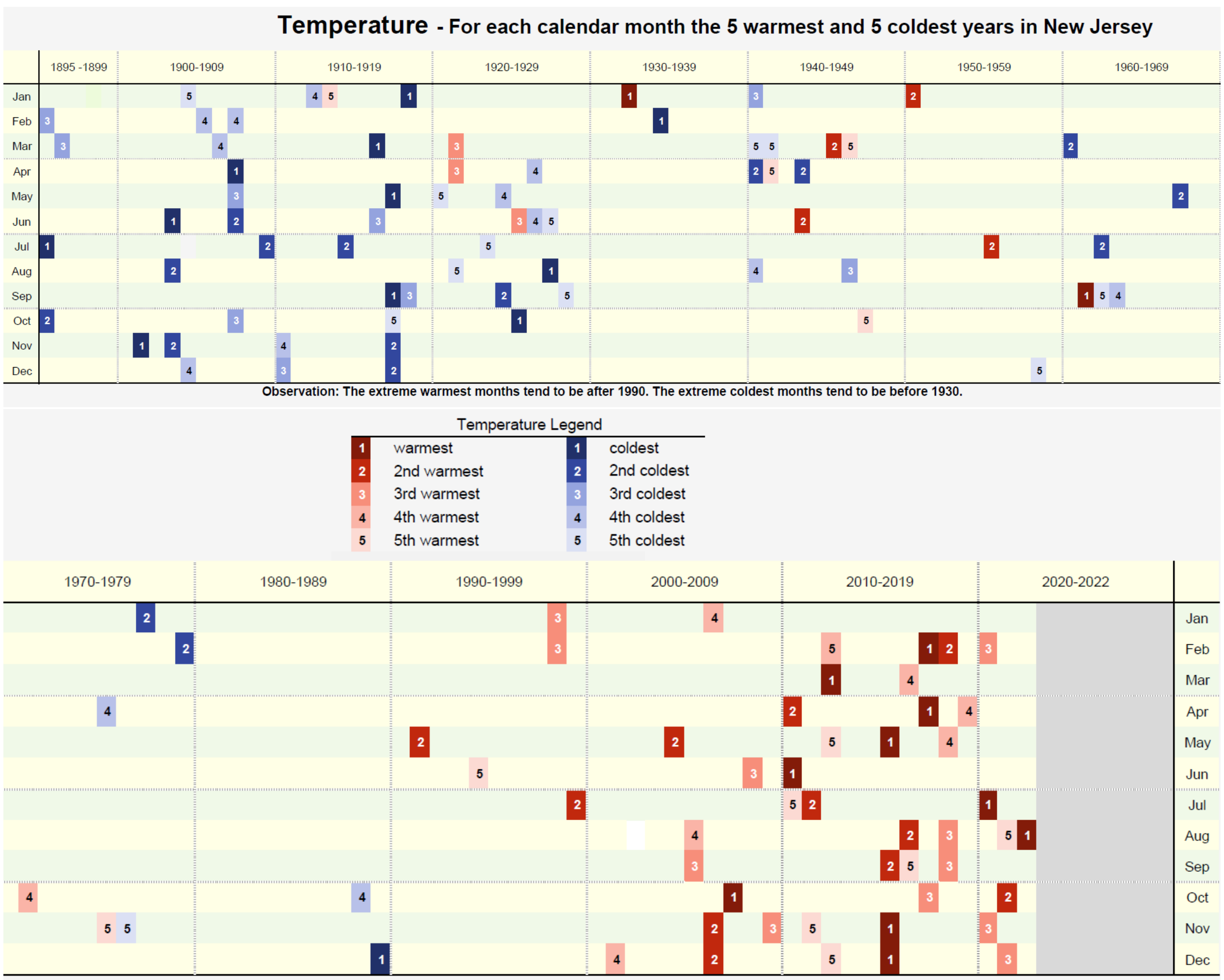

Figure 3.1 New Jersey's Extreme Temperature Months, 1895-2022 (Rutgers/NJDEP-NJG&WS, 2023).

PRECIPITATION

Precipitation above all else drives water availability and the timing and magnitude of it is critical in determining water supply impacts. Extreme events can provide a lot of runoff into reservoirs but it can also cause flooding and negatively impact water quality or water supply infrastructure. Lack of precipitation beyond normal amounts can lead to drought, stress aquatic resources, and reduce water

available for consumption. Precipitation in New Jersey has increased roughly 7% since the early 1990s (Figure 3.2). It is evident in Figure 3.2 that precipitations patterns often demonstrate variability when examined year-to-year or by location. This variability can make it difficult to directly attribute all of the recent increases to climate change, but there is an increasing trend in precipitation in which climate change is the driving factor. Looking to the future, the 2020 New Jersey Scientific Report on Climate Change states annual precipitation in New Jersey is expected to increase by 4% to 11% by 2050 (Horton et al., 2015).

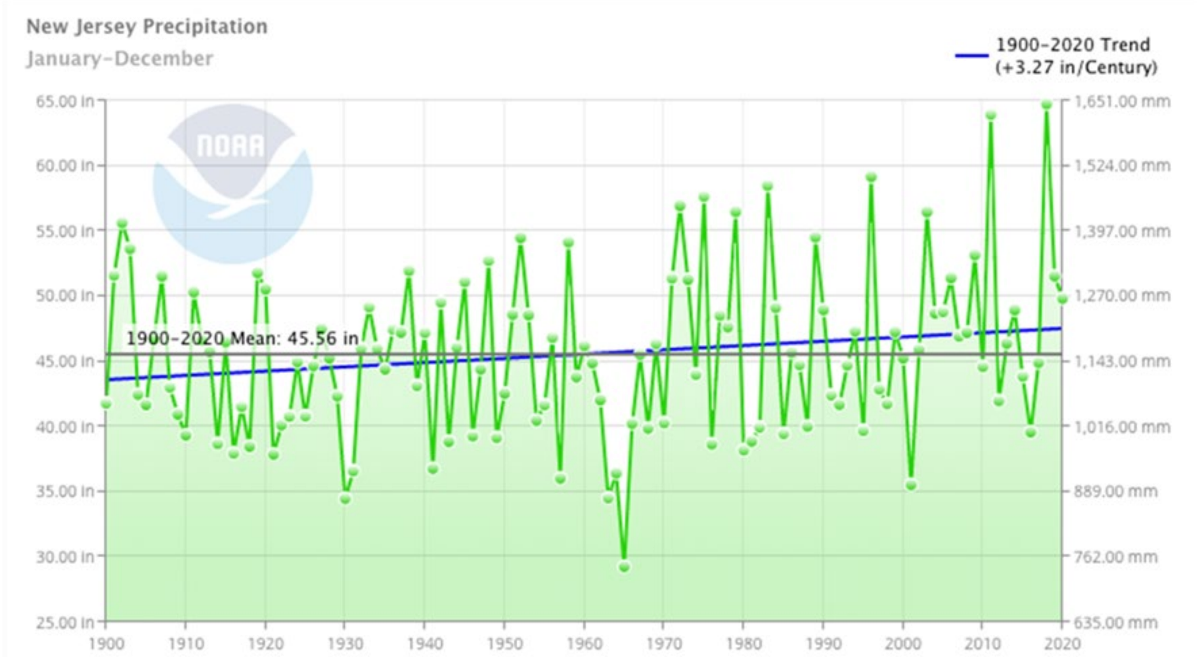

Figure 3.2 New Jersey Annual Average Precipitation 1900-2020 (NOAA National Centers for Environmental Information).

EXTREME PRECIPITATION

The increase in annual precipitation totals observed since the 1990's is generally not concerning from a water supply standpoint. More precipitation means more available water, which is typically a favorable condition. However, over recent decades some locations have exhibited a tendency for an increasing percentage of annual precipitation to occur during larger precipitation events. Instead of annual precipitation totals building though numerous small-scale events, more and more often extreme events comprise a greater percentage of the annual total. To visualize how New Jersey will be impacted by the increased intensity of extreme precipitation events throughout the next century DEP commissioned the creation of the New Jersey Extreme Precipitation Tool. With larger scale precipitation events comes elevated risks of flooding and flood-related damage (e.g., existing infrastructure). Recent projections indicate that the intensity of precipitation events in New Jersey will continue to increase and that changes will be greater in the northern part of the state than the southern and coastal areas (DeGaetano, 2021).

Additionally, the extreme 24-hr rainfall will increase by about 5–15% and despite increasing rainfall annually, rising temperatures and increases to water demand and evaporation will likely increase the

likelihood of drier soil conditions overall (DeGaetano, 2021). In addition, the frequency and intensity of short-term, very dry to drought conditions are likely to increase (Shope et al., 2023). The juxtaposition of short, intense precipitation events and flashy hot, dry periods, and how the two phenomena influence each other, create significant challenges for water supply managers, who must determine the impacts to supply not necessarily over an annualized period, but over relatively short time scales. The ability to make assessments seasonally, monthly, or even weekly becomes more important. Thus, additional development of higher resolution, more time-sensitive, models is needed. Similar variability may develop across the state at different rates and intensities, further complicating the situation. Research conducted as part of this Plan has predominantly focused on the annual time step and the next step is to apply GCMs via downscaling to address these critical issues.

TEMPERATURE AND PRECIPITATION NEXUS

Temperature and precipitation, and more specifically the combination of both, are closely linked with hydrologic and water supply conditions in New Jersey. In the southwestern United States, data and GCMs show the high probability of long-term reductions in precipitation and increasing temperatures resulting in severe water availability reductions. The same cannot be said for New Jersey. While warmer temperatures lead to longer growing seasons and higher water demands, increases in annual precipitation equate to more available water. Short-term (weekly, monthly, seasonal and year-to-year specific) variability in these two quantities can have significant impacts on water supply conditions in the state at any time. Neither the GCMs nor the long-term weather forecast models are accurate enough yet to predict when these unique combinations of hot and dry will occur. This is further complicated by the fact that the time of year is an important factor in determining their hydrologic impact. Hot and dry weather in the spring can increase forest fire risk or complicate agricultural practices, and hot and dry weather in the summer can increase demands and stress water supplies. It is the latter, the hot and dry in the summer, that at least anecdotally appears to be occurring more frequently. The occurrence of these short, but severe events, sometimes referred to as 'flash droughts', can cause different types of droughts (refer to Chapter 7) to emerge and require the development of specific indicators and metrics to more reliably determine when they are occurring and improved research to determine their recurrence interval.

SEA LEVEL RISE

Sea-level rise in New Jersey is affected by at least three different factors. One is global and regional ocean level rise due to warming of the oceans (expansion) and increased ice melt. The second is movement of the earth's crust in New Jersey, where the northern area is slowly rebounding from removal of the ice sheet weight from the last glaciation and the southern area is sinking (a process known as isostatic rebound). The third is historic reduction of groundwater pressure in coastal confined aquifers, which can result in land subsidence.

Rising sea levels can temporarily or permanently turn fresh water sources salty, inundate water supply infrastructure, and make 'normal' flood events even more devasting. New Jersey has already been disproportionately affected by the apparent rate of sea-level rise with projections in New Jersey being more than two times the global average (NJDEP, 2020). Gauge heights in several locations within New

Jersey illustrate this rise (Figures 3.3 a-c). As part of its evaluation, Rutgers determined that sea-level has risen 18.2 inches from the year 1911 at Atlantic City (Shope et al., 2023) compared to the average of 7.6 inches globally over a similar time period. For the more recent 40-year period from 1979 through 2019, sea-level has risen 8.2 inches at Atlantic City, compared to an average of about 4.3 inches globally (Shope et al., 2023). Sea level has risen by an average rate of approximately 0.2 inches per year along New Jersey's coast while the global average has been about 0.1 inch per year.

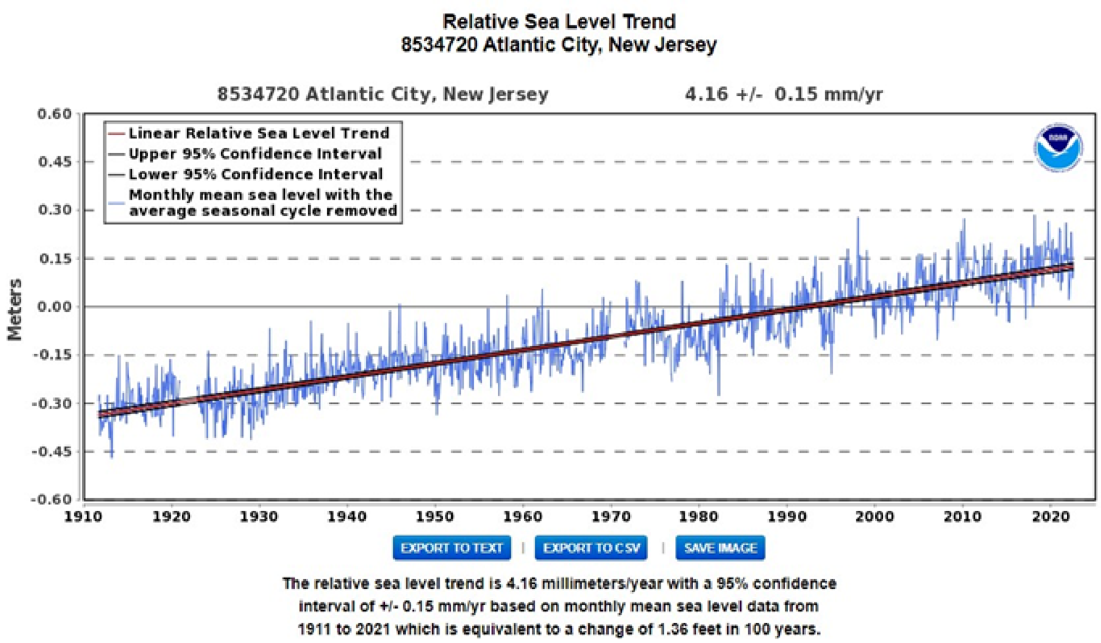

Figure 3.3a Sea level Trend for Atlantic City (NOAA).

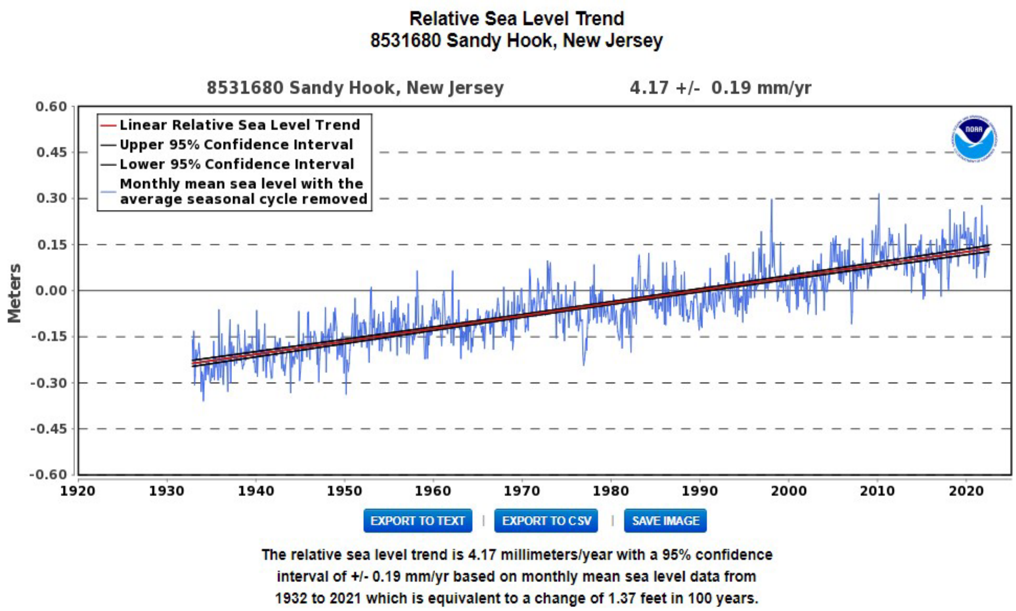

Figure 3.3b Sea level Trend for Sandy Hook (NOAA).

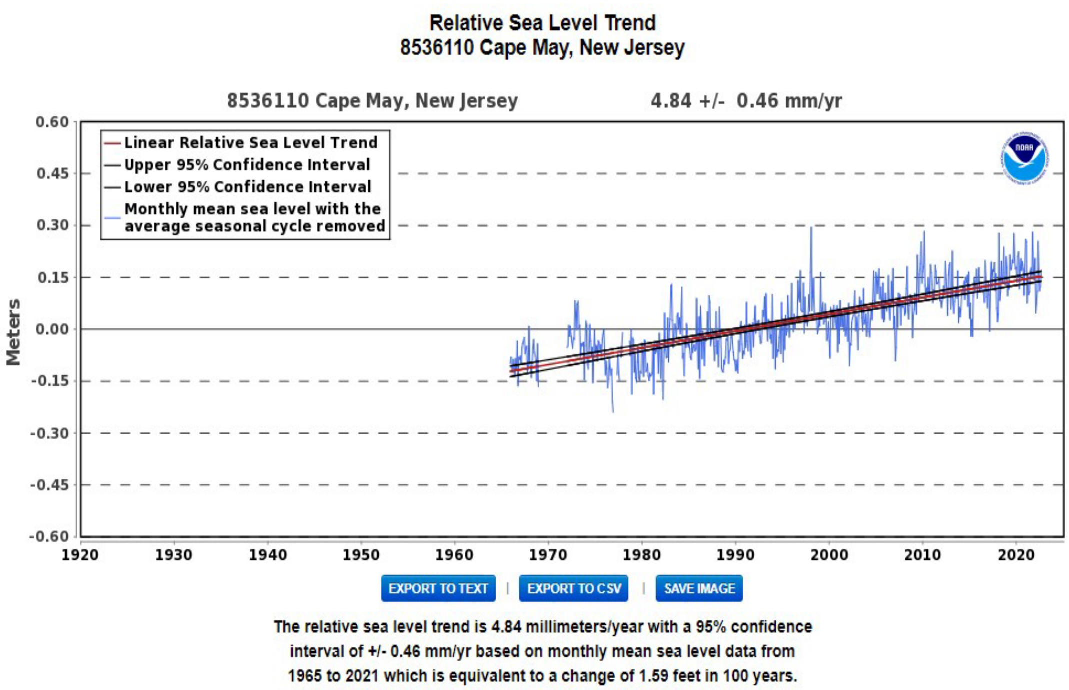

Figure 3.3c Sea level Trend for Cape May (NOAA).

The rate of sea-level rise has been accelerating in recent decades and is expected to further accelerate through this century (Shope et al., 2023). Sea-level rise in New Jersey is projected to increase from levels experienced in the year 2000 by up to 1.1 feet by 2030, 1.4 to 2.1 feet by 2050 (50% and 17% probability,

respectively), and 3.3 to 5.1 feet by 2100 due to climate change using a moderate emission scenario (NJDEP, 2020), as shown in Figure 3.4 for a set of probability curves.

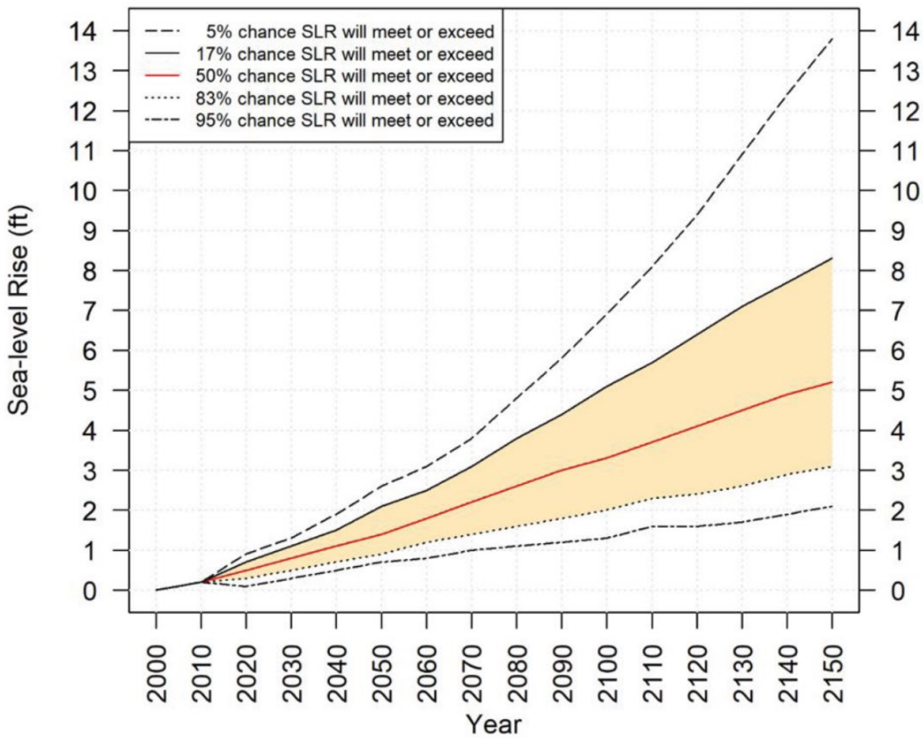

Figure 3.4 Diagram of Sea-Level Rise Projections Curve Under Moderate Emissions Scenario *(Kopp et al., 2019)*. *There is a 50% chance that sea-level rise will exceed the level displayed by the red line, and a 66% chance that sea-level rise levels will be between the solid black line and the dotted black line (i.e., tan area). (As shown in NJDEP, 2020.)*

The most recent Rutgers report notes that the rate of sea-level rise from 2050 through 2100 is more dependent on future greenhouse gas emissions, stating: "In a low emissions scenario, projected sea-level rise at 2100 is expected to be 1.7–4.0 ft compared to the year 2000. Under a high emissions scenario, sea level is projected to rise 2.3–6.3 ft." (Shope et al., 2023).

CLIMATE CHANGE IMPACTS RELEVANT TO NEW JERSEY WATER SUPPLY

The pervasive nature of climate change will impact the state's water supplies in several ways. First, sea level rise (SLR) may increase saltwater intrusion of coastal aquifers and estuaries, or it may inundate coastal wells and other critical water treatment and distribution infrastructure. Second, changing precipitation patterns, especially the increase in large events, which lead to flooding can damage water supply infrastructure or impact raw and finished water sources. Additionally, changing precipitation combined with increased temperatures may alter surface water safe yields and groundwater recharge

and aquifer dependable yields. These changes may also lead to worse and/or more frequent drought periods. Third, climate change may alter surface and ground water quality (Aziz, 2023) which can lead to increased treatment times and costs. This would include warmer water temperatures increasing the likelihood of harmful algal blooms (HABs) caused by cyanobacteria which has become more and more of a problem over the last decade. Fourth, altered water use patterns may result, especially in outdoor water uses such as agricultural and non-agricultural irrigation. The relationship between climate change, water resource impacts, and specific impacts to water supply is complicated. A schematic showing these relationships is shown in Figure 3.5. The current scientific evidence and issues regarding these issues are discussed in this section.

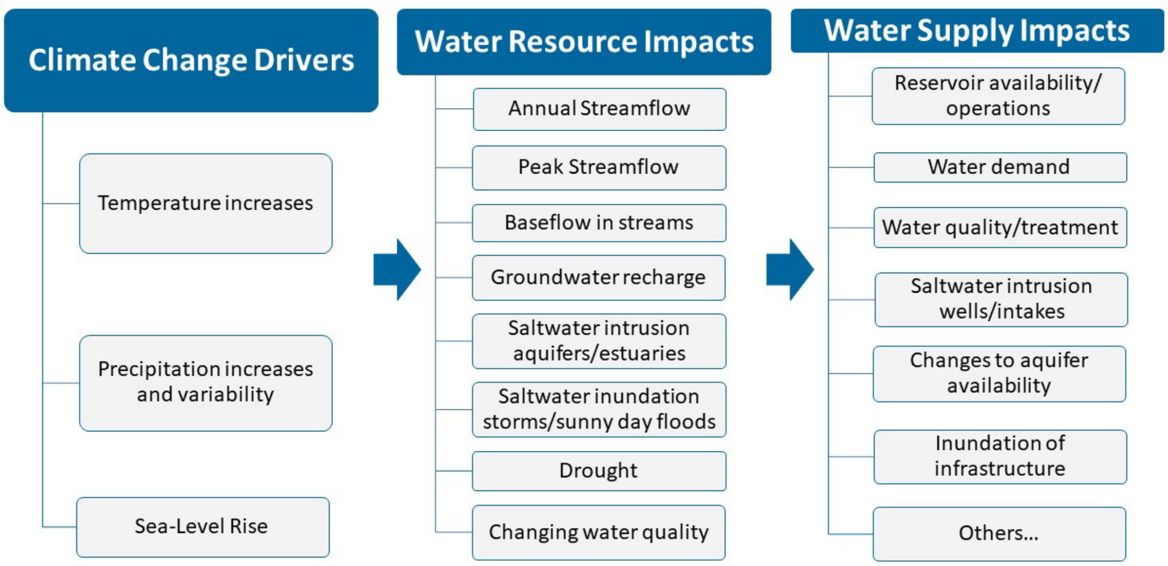

Figure 3.5 Shows flow from climate change drivers to potential impacts to water supply.

COMPLEXITIES OF WATER RESOURCES AND CLIMATE CHANGE

Past conditions are no longer good indicators of future conditions, and predicting the future is complicated by the interaction of multiple climate change impacts, each with its own pattern and trends. Therefore, the implications for water supply and demands are not straightforward. For example, increased precipitation can increase water supply, especially for our larger reservoir systems, but increased dry periods would stress supplies, especially for smaller reservoirs and shallow aquifers. Increased storm intensity can overwhelm soil capacity for infiltration, resulting in a greater percentage of precipitation going to runoff rather than aquifer recharge, but that effect may be offset by increasing precipitation overall. Total groundwater recharge may be reduced by the longer growing season (where water needs of plants reduce infiltration beyond the root zone), but recharge may be increased by more precipitation coming as rainfall during milder winters. Any of these patterns may also change as the relative change in precipitation and temperature shifts.

Another uncertainty is whether climate change will raise the potential for increasingly severe droughts in New Jersey, and whether they could result in a new worse drought of record. A related question is whether the potential for more frequent but less severe droughts will stress water resources in ways not previously seen. In other words, is the multi-year dry period the most limiting factor for future supplies, or will a shorter, but more severe dry period or a combination of smaller droughts in close proximity be the new drought of record?

Regarding water demands, warmer temperatures mean longer growing seasons and increased demands for lawn and agricultural irrigation, exacerbated by more dry periods during the growing season. Intense storms may be less useful for crops than long periods of milder rainfall. To the extent that irrigation occurs during dry summer periods, increased water supply stresses will occur at the driest time.

Water supplies are highly dependent on the seasonal and total amounts of runoff (supporting reservoir storage), groundwater recharge (supporting aquifer storage), and movement of groundwater into surface waters to support stream flows (supporting reservoir storage and aquatic ecosystems). Researchers must therefore understand the extent to which conditions have already changed (and whether the changes are accelerating), the potential for conditions to change into the future, and how the various changes for individual variables will affect water supplies. On the demand side, researchers must understand how climate change has altered and may alter water demands, as changing demand patterns and intensity could reduce reservoir safe yields and aquifer sustainability.

An overhead agricultural irrigation system at Tuckahoe Turf Farms in Hammonton, New Jersey. Climate change may increase water demands for agricultural irrigation by extending growing seasons and increasing the frequency of dry periods during the growing season.

Climate change is increasing variability and uncertainty and leading to new weather extremes. Certain combinations of these weather events can cause major water supply impacts. These new extremes are difficult to plan for as there are no historical analogs that can be used as examples. When two or more of these extreme events occur

simultaneously, they are referred to as "black swan events" and can be thought of as situations where compounding events caused by weather extremes, such a HAB occurring during a drought, may test water supply systems in ways never imagined. However, water supply managers should not be deterred from prudent planning as inaction would be an unfortunate and costly response to uncertainty. Rather, managers can look to past instances where water supply conditions were put under great strain, be they due to extreme weather conditions or the inability for existing infrastructure to adequately perform, and see that one of the best defenses against severe events is the maximization of flexibility within a water system. The ability to quickly move water from one source to another via well designed and protected infrastructure is vital in these situations.

SEA-LEVEL RISE AND RESULTING IMPACTS

Sea-level rise will have the largest impact along the New Jersey coastline and especially in southern coastal areas along the Jersey Shore and Delaware Bay and estuary. Three major impacts are discussed in this section: confined aquifers, unconfined aquifers, and water supply wells.

Changes in sea level can affect the groundwater flow system by altering the extent and location of the freshwater-saltwater interface within the New Jersey Coastal Plain aquifers in several ways. This interface is where the freshwater portion of the confined or unconfined aquifers are met by more saline waters that are associated with the sea. Changes to the location of this interface are caused by a combination of factors including aquifer recharge rates (both natural and as affected by land uses), water withdrawal rates, and sea-level rise (both natural and as affected by climate change).

As a general approach to characterize and assess sea-level rise in this Plan, the two-foot and five-foot increases are used as the basis for 2050 and 2100 assessments, respectively. These estimates are generally consistent with DEP's Sea-Level Rise Guidance document from June 2021 assuming a moderate emission scenario. It is critical to note that this guidance document outlines a more evolved process to select an appropriate SLR estimate that factors in risk tolerance, project lifespan, and geographic location, among other factors, when assessing a specific project. DEP's guidance also recommends considering the 2100 horizon. However, other key aspects of this Plan (such as the water demand forecasts) focus out to 2050 only. Since the Plan is required to be updated every five years and many of the climate change-water supply impacts assessments are new, many of the analyses are limited to the 2050 period. Where appropriate, the 2100 time period is considered in this Plan. DEP will enhance existing water availability models and leverage expanded knowledge of SLR for future updates, and will consider current policies, procedures, guidance, and longer forecast periods.

UNCONFINED AQUIFERS

The shallow coastal aquifers are at greatest risk of sea-level rise impacts. Sea-level rise translates directly to a movement of saline water over currently dry lands. The more the saline waters move inland, the greater the loss of recharge area and the greater the potential for movement of saline waters into groundwater. Dissolved salts make saline water denser causing it to sink beneath freshwater, so rising sea levels can push it further inland under fresh groundwater. The shallower the slope of a land area, the greater the in-land penetration of saline waters from sea-level rise. For example, a slope of one foot per

thousand feet means that one foot of sea-level rise will equate to the inland movement of saline waters one thousand feet. Southern portions of the Jersey Shore and much of the Delaware Bay shoreline in Cape May, Cumberland and Salem counties typically have very shallow slopes from the water's edge. Combined with the effects of storm surges, large areas can be placed at risk as can be seen in Figure 3.6, adapted from the New Jersey Climate Change Resource Center's NJFloodMapper tool.

Figure 3.6 Delaware Bay Inundation, (L) Current and (R) 2-Ft Sea-Level Rise (NJCCRC).

CONFINED AQUIFERS

The nature of the freshwater-saltwater interface over the past 84,000 years is described in reports completed by Pope and Gordon (1999), Meisler et.al. (1985 and 1989), and Spitz (1998). These studies detailed the location of salty groundwater in both onshore and offshore areas in the Northern Atlantic Coastal Plain and the effects of eustatic sea-level changes (i.e., based on the global volume of ocean water) on the location of this freshwater-saltwater interface within the aquifers.

Greater degrees of heterogeneity within the coastal plain sediments would cause the freshwater flow system to extend farther offshore. Simulations using decreasing hydraulic conductivity in the sediments offshore suggest that the saltwater interface zone in the adjacent Continental Shelf in southern New Jersey is not in equilibrium with present sea level and most likely represents sea levels that were 50 to 100 ft below present sea level. Meisler et.al. (1984) concluded that the freshwater-saltwater interface is not in equilibrium with present sea level due to the influence of significantly lower sea levels that have occurred in the more recent geologic past and that the current interface is moving landward in response to the geologic changes in sea level from 71,000 years ago. More recent studies of sea level during the last glacial age indicate that the lowest sea levels were in the range of 120 to 135 meters (394 to 443 feet) below current global levels (Lambeck, et al., 2014). As sea level began to increase from 71,000 years ago to the present, the freshwater-saltwater interface began moving landward. The saltwater interface transition zone is currently moving slowly landward and upward in response to the most recent rise in sea level with the estimates of lateral water particle velocity at a rate of about 0.2 miles per 10,000 years (Meisler, 1989).

Pope and Gordon (1999) examined more recent changes and scenarios related to sea level using the SHARP modeling program to simulate flow between freshwater and saltwater sources for scenarios representing past eustatic conditions and future groundwater withdrawals on the location of the saltwater interface. The SHARP model is a quasi-three-dimensional, finite-difference model that simulates coupled freshwater and saltwater flow separated by a sharp interface which is used to represent the difference in chloride concentration between fresh and salty water (Essaid, 1990). This model was used to represent the hypothetical seaward extent of which the chloride concentration is equal to or greater than 10,000 milligrams per liter in the New Jersey Coastal Plain aquifers.

Simulations were used to estimate the location and movement of the interface for several scenarios; geologic sea-level changes for the past 84,000 years, pumping impacts within the aquifers from predevelopment time and the potential impact of future withdraws through the year 2040. No future sea-level rise scenarios were simulated as part of this study, but the model simulations do provide a description of the location and movement of the salt-water interface during historical sea-level changes and water-use increases. At the end of the USGS simulation for this time period, the freshwater-saltwater interface was moving geologically up-dip from the rise in sea level beginning 18,000 years ago to sea level in 1896, which represents the sea level elevation at the first point of accurate measurement specific to New Jersey. Since that time to the end of the study, the saltwater interface has been moving landward in response to sea level rise. However, the current saltwater interfaces for most confined aquifers used in coastal regions in New Jersey are located tens of miles offshore.

These modeling studies verify that the movement of the freshwater-saltwater interface is most influenced by large scale, geologic changes in sea level resulting from changes in glaciation. These past geologic sea-level changes indicate that a relative 2-ft increase in sea level by 2050 would not significantly reduce the source of fresh groundwater within the confined aquifers in the New Jersey Coastal Plain by saltwater displacing freshwater. The modeling also concluded that the movement of the saltwater interface is not overly sensitive to stresses on the groundwater flow system resulting from increased groundwater withdrawals from the Coastal Plain aquifers. While sea-level rise over the next 50 years does not appear to substantially exacerbate the risk, additional research should be conducted to confirm these findings. Similar findings for 2100 estimates of sea-level rise would also be true. Periodic monitoring and reassessment are still required to ensure that the most up to date projections and groundwater models are utilized to confirm these conclusions.

It is critical to note that aquifers which are currently experiencing or expected to experience saltwater intrusion in the short-term will still need to be actively managed and monitored. Refer to Chapter 6 for a discussion of these areas/aquifers and how DEP is managing them.

POTENTIAL IMPACTS TO NEW JERSEY'S AQUIFERS

Shallow, unconfined aquifers, including outcrop areas of confined aquifers, would be the first immediate threat to a direct rise in sea level and landward inundation. New Jersey Geological and Water Survey (NJGWS) staff used the DEP Sea Level Rise Inundation Depth Grid (NJDEP, 2021) for 2-ft and 5-ft sea-level rise to analyze the potential impacts to New Jersey's aquifers from the direct inundation of sea water for the year 2050 and 2100 SLR conditions, respectively. The Depth Grids were generated by DEP's Bureau of

GIS based on the National Oceanic and Atmospheric Administration's (NOAA) mean higher high water (MHHW) surface. Grids were then superimposed over existing GIS coverages including aquifer outcrop areas and public supply well locations to provide an analysis into the immediate impacts from sea water inundation. The immediate and principal impact of a 2 or 5-foot increase in sea level on New Jersey's aquifers would occur in the unconfined aquifer systems of the Coastal Plain. The unconfined Kirkwood-Cohansey (K-C) aquifer system would suffer the greatest harm, as it covers a very large portion of the Coastal Plain of New Jersey. Based on the analysis, approximately 77,400 acres of the K-C aquifer would be directly inundated by sea water from a 2-ft sea level rise (Figure 3.7). The impacted regions are located along coastal areas and tidal waterways along the Atlantic Ocean, Delaware Bay and tidal Delaware River. This inundated area would also provide a direct pathway for the migration of sea water towards freshwater sources used by existing unconfined wells, which are numerous in these regions (see Tables 3.1 and 3.2).

Confined aquifers with outcrop areas, where a water bearing layer nears the ground surface and can be recharged directly by precipitation, which extend to these mapped inundated areas would also create a direct pathway for the infiltration of sea water into fresh water sources. The confined aquifer outcrop areas that would be initially affected by inundation include the Magothy and Potomac Formations. They run parallel to the Delaware River and the aquifers currently exhibit some degree of hydraulic connection with the river. The 2-ft SLR would inundate approximately 9,000 acres of the outcrop area of the Magothy and 5,100 acres of the Potomac Formations (Figures 3.8 and 3.9 respectively). Again, any inundation of salt water at these outcrop areas would provide a direct pathway for salty water to migrate towards fresh water sources, aggravating any current salt-water intrusion that currently exists. Groundwater flow direction in these aquifers has historically been controlled by the large cone of depression due to previous over pumping that led to the declaration of Water Supply Critical Area 2 and the imposition of regulatory controls on, and reductions of, confined aquifer use. This large cone of depression has shifted flow from predevelopment when groundwater discharged to the river to the current flow pattern of inland and down dip flow in these units. The inundation of brackish water from a 2-ft or 5-ft SLR increase would provide a pathway for salty water to migrate towards pumping centers due to the increased particle velocities created by large cones of depression. The area with the greatest cone of depressions in both the Magothy Formation (Upper PRM Aquifer) and Potomac Formation (Lower PRM Aquifer) is currently located within inland Camden County between Lindenwold and Pine Hill.

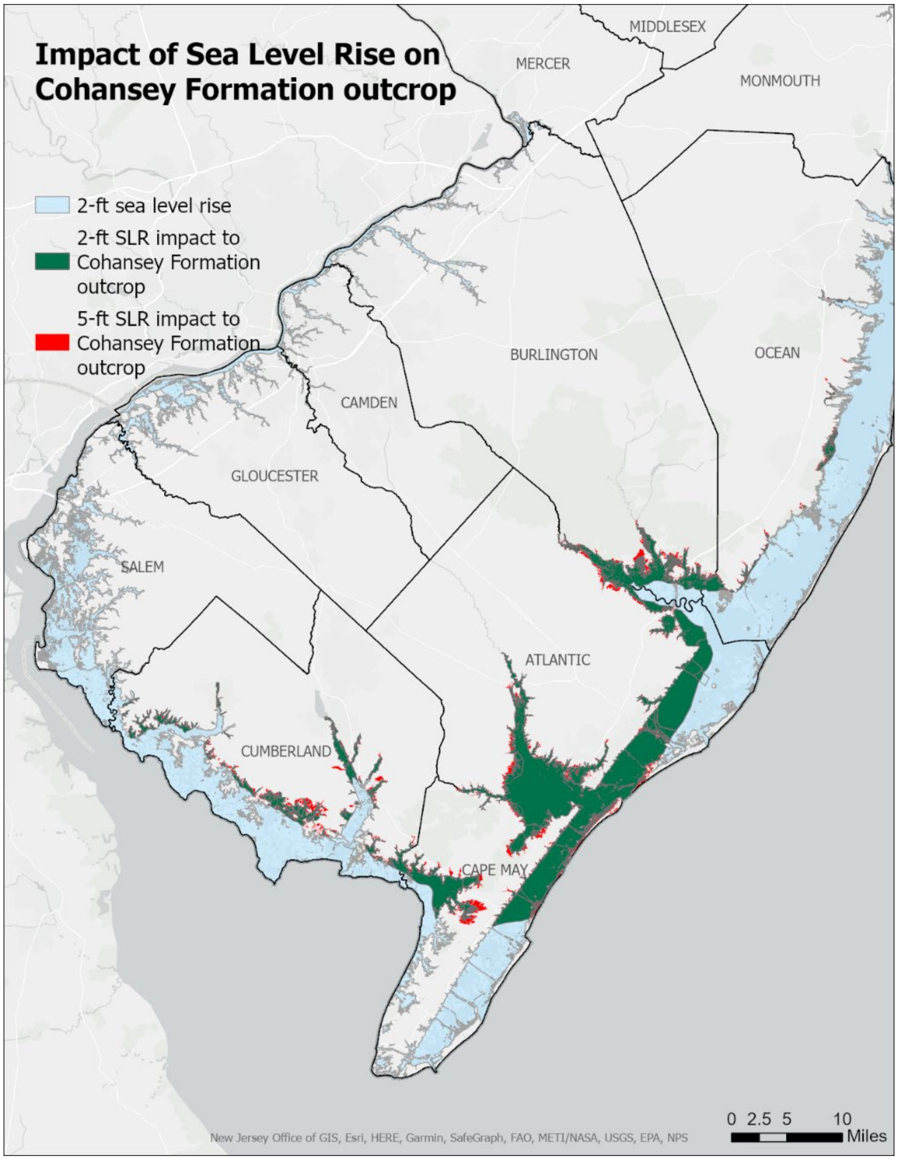

Figure 3.7 Inundation area impacting Cohansey Formation outcrop for 2-ft and 5-ft of sea level rise.

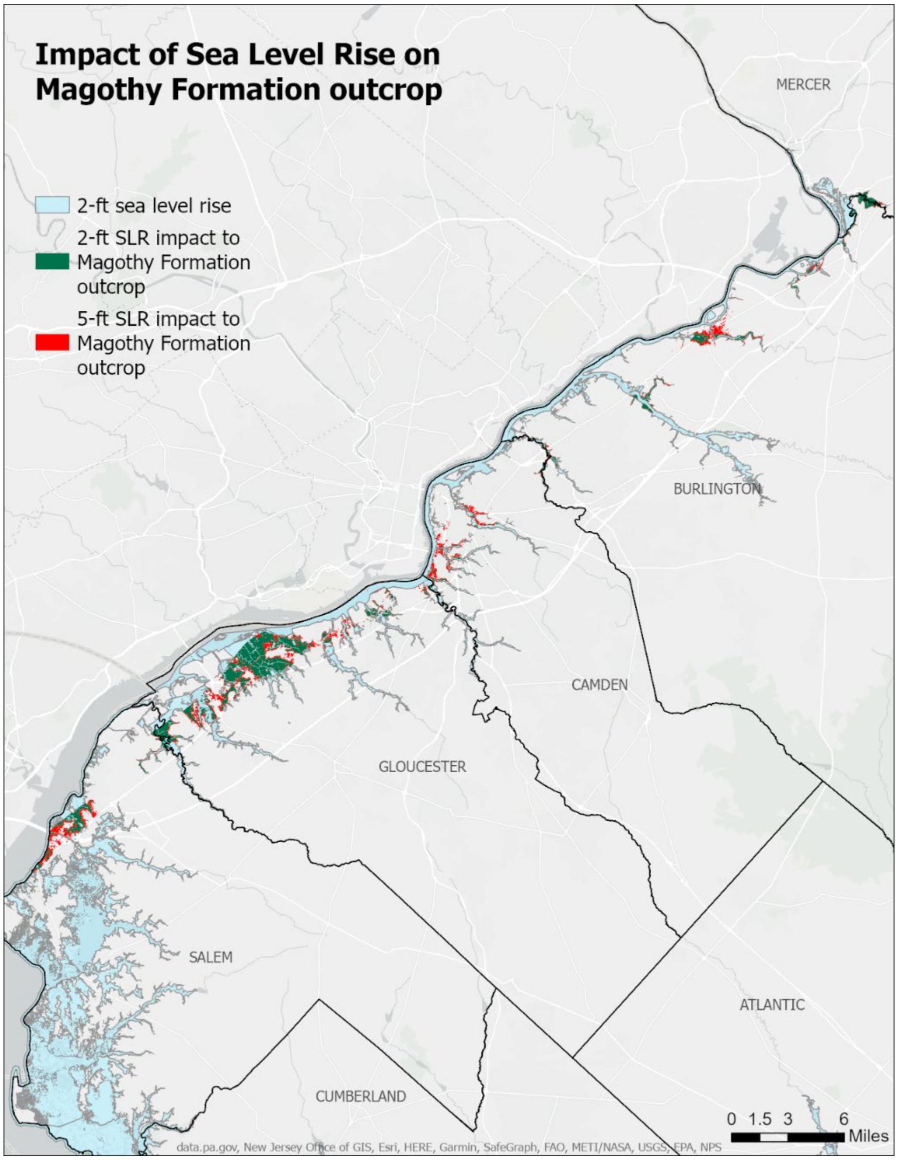

Figure 3.8 Inundation area impacting Magothy Formation outcrop for 2-ft and 5-ft of sea level rise.

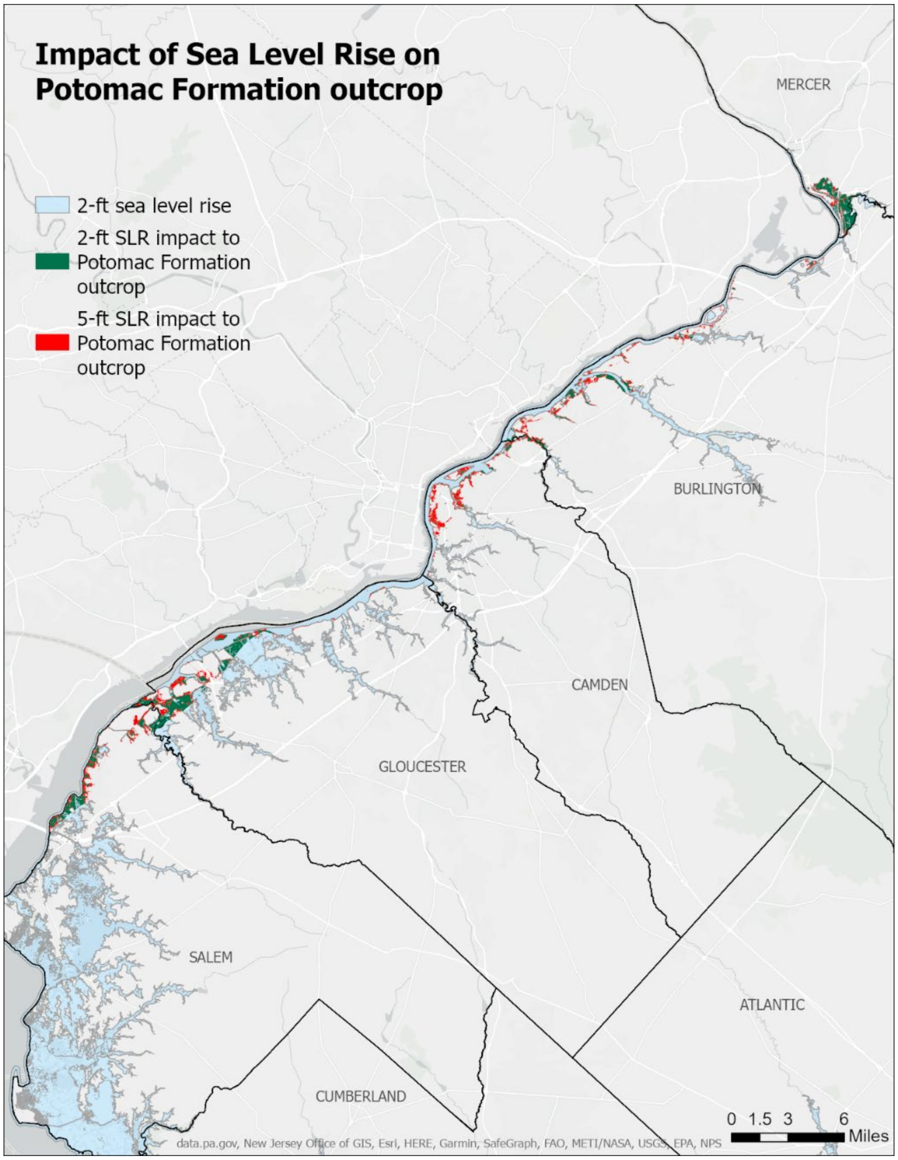

Figure 3.9 Inundation area impacting Potomac Formation outcrop for 2-ft and 5-ft sea level rise.

POTENTIAL IMPACTS TO EXISTING WELLS AND INTAKES

The immediate impact from a two- or five-foot sea level rise impact would be to unconfined wells with a direct connection to the surface. However, confined wells would also be prone to direct inundation of sea water from the wellhead, which could provide a pathway for vertical migration of salty water to deeper confined and not-salty water.

Confined aquifers along New Jersey's Atlantic coastal regions currently contain significant volumes of freshwater with the saltwater front located miles offshore. Salt-water intrusion in coastal aquifers from the projected SLR for 2050 does not appear to be a factor due to the location of the saltwater interface and the previous modeling study results. The USGS modeling studies concluded that increasing pumping by 30 percent to simulate potential 2040 withdrawal volumes would have little impact on the position of the current salt-water interface within New Jersey aquifers. For example, the 10,000 mg/l chloride line for

the Atlantic City 800 ft sand aquifer is currently mapped more than 30 miles offshore. Therefore, no barrier island confined aquifer wells along the Atlantic coast are likely to be at risk if the wellheads themselves are not subject to inundation, but other areas with saltwater intrusion remain a concern.

Existing regional groundwater flow models could be used to simulate areas where salty water may be a concern by using advective transport to further analyze what areas outside of the 2050 projection may be prone to salt-water migration. These models could also be used to look at future water demands and existing cones of depression impacts on the 2-ft SLR inundated areas. Areas that are currently dealing with saltwater intrusion within New Jersey such as Cape May County would need to evaluate the additional impact that a 2-ft SLR will have on their groundwater resources.

The potential for 5-ft of SLR by 2100 puts many wells, in both confined and unconfined aquifers, at risk. Figure 3.10 highlights the threat for confined aquifer potable supply wells along the barrier islands and shows that there is also significant risk to surface water intakes and unconfined groundwater wells near the Delaware Bay and River. In Figure 3.11, the withdrawal sites are symbolized by use group. Impacted wells for agricultural use are clustered along the Delaware Bay and River while those along the Atlantic coast are more likely to be used for potable supply. The number of wells that are within the 2- and 5-foot areas are summarized by their source of water in Table 3.1 and by their use of water in Table 3.2. Although they are not displayed on the maps or tables, the NJGWS water use database, NJWaTr, estimates that 18878 domestic wells would be inundated by 5-ft of SLR.

Although outside the scope of the current Plan, future vulnerability analyses can be conducted to examine the potential risk of SLR-related water supply problems due to aquifer loss and increased stress on surface water supply systems. For example, a similar vulnerability analysis approach used to create Figure 2.14 can be updated to include potential saltwater inundation from sea level rise.

Table 3.1 Number of Wells Within the 2- and 5-foot Sea-level Rise Zones by Source of Water

Source of Water	2-ft SLR		5-ft SLR	
	Well count	Volume (mgd)*	Well count	Volume (mgd)*
Confined	23	7	132	29
Unconfined	35	2	140	10
Surface	70	21	100	40
Unknown	0	0	1	0
Total	128	30	373	79

*Annual volumes (2016-2020) were averaged for each site then summed by source type.

Table 3.2 Number of Wells Within the 2- and 5-foot Sea-level Rise Zones by Use of Water

Use of Water	2-ft SLR		5-ft SLR	
	Well count	Volume (mgd)*	Well count	Volume (mgd)*
Agriculture	70	2	100	3
Commercial	3	0	5	0

Use of Water	2-ft SLR		5-ft SLR	
	Well count	Volume (mgd)*	Well count	Volume (mgd)*
Industrial	27	19	70	32
Irrigation (non-ag)	10	0	33	0
Mining	0	0	5	6
Potable supply	18	9	158	38
Power generation	0	0	2	0
Total	128	30	373	79

*Annual volumes (2016-2020) were averaged for each site then summed by use type.

Water supply is much more than wells and intakes and consideration needs to be given to the entire withdrawal-transfer-treatment-delivery infrastructure network. While detailed location data for finished water infrastructure does not reside in one master GIS database, DEP identified approximately 340 finished water storage tanks, standpipes or similar structures associated with public community water systems within the 2-ft sea level rise zone. These structures range in size from 1,000 gallons to over 10 million gallons and total over 500 million gallons of combined storage. These supplies are key assets and ensure that drinking water can be delivered during peak demand periods or when treatment is offline. Additional data should be compiled to identify pump stations, treatment plants and other critical water supply infrastructure threatened by sea-level rise or freshwater flooding. The data and subsequent analysis are needed so DEP can identify an action plan and prioritize next steps.

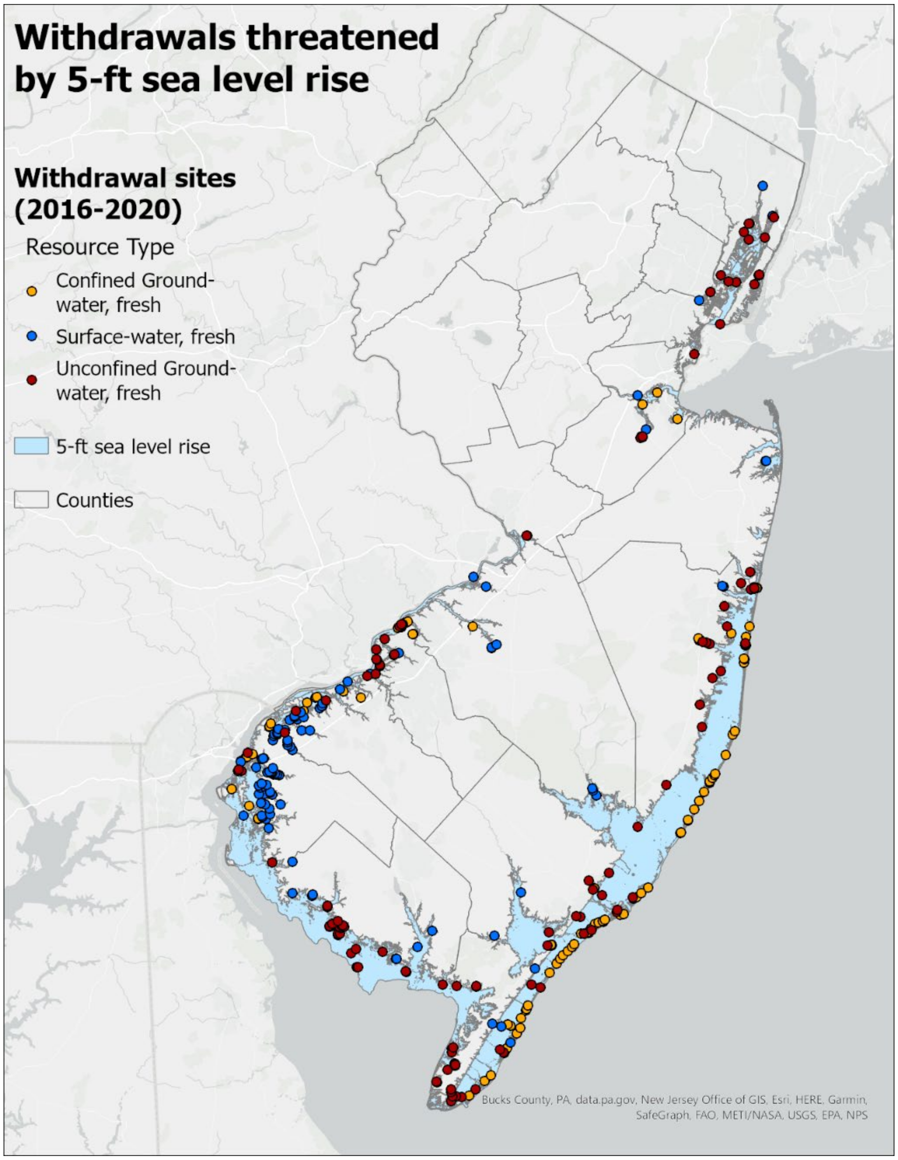

Figure 3.10 Water withdrawal sites inundated by 5-ft of SLR, symbolized by resource type.

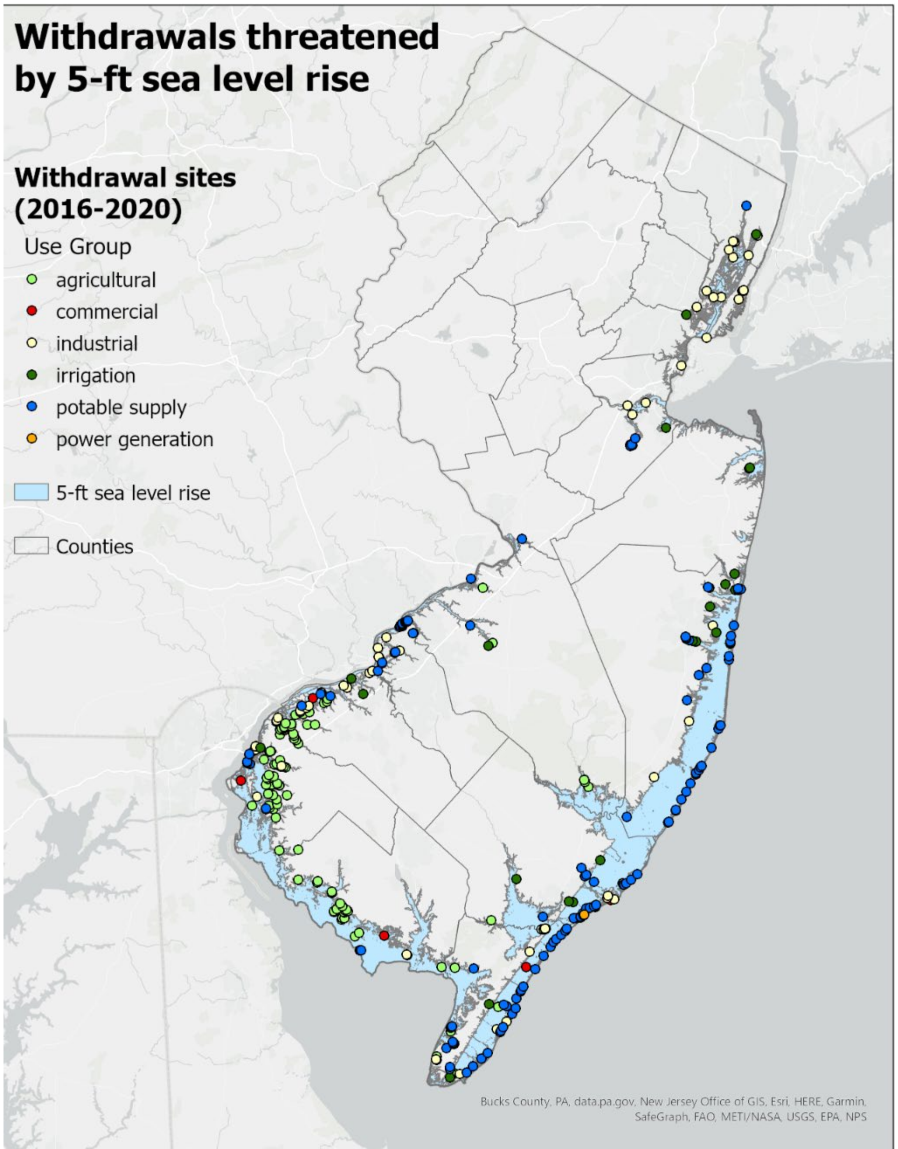

Figure 3.11 Water withdrawal sites inundated by 5-ft of SLR, symbolized by use group.

POTENTIAL IMPACTS TO DELAWARE RIVER WATER SUPPLIES

The Delaware River Basin surface water supplies is a major water supply for New York City, the City of Philadelphia, and multiple New Jersey water systems including the City of Trenton, the New Jersey Water Supply Authority's Delaware & Raritan Canal, New Jersey American Water Company's Delran intake, as well as host of smaller surface water users. Flows in the river and out of basin diversions are governed by a complex set of rules which were initially established by a 1954 Supreme Court Decree and then changed in response to the 1960's drought of record by the 1983 Good Faith Agreement (GFA). The GFA rules have been modified by a subsequent series of agreements, the most recent being the 2017 Flexible Flow Management Program (FFMP). The program works in conjunction with the regulations and dockets of the Delaware River Basin Commission to manage the water resources of the Delaware River Basin. One of the key provisions of the current agreement are the salt-vernier procedures which require increased reservoir

releases under certain conditions to help keep the location of the 250 mg/L chloride concentration line away from the potable intakes in the estuary (namely the New Jersey American Delran and City of Philadelphia intakes). More information can be found with the United States Geological Survey's Office of the Delaware River Master (Office of the Delaware River Master) and with the Delaware River Basin Commission (Delaware River Basin Commission).

In the drought of the 1960s, salt water came very close to impacting the Philadelphia water intake and would have impacted the New Jersey American Delran intake if it had been built then. As sea level rises, saltwater will migrate further upstream, requiring additional management actions to offset this effect (Figure 3.12). The parties to the Good Faith Agreement and the DRBC are assessing how climate change will increase, decrease, or complicate the delivery of water supplies while meeting the salt front management goals (Delaware River Basin Commission, 2019). The DRBC and USGS are providing modeling support for these assessments and the Parties have agreed to assess the salt vernier procedures to determine if modifications should be made.

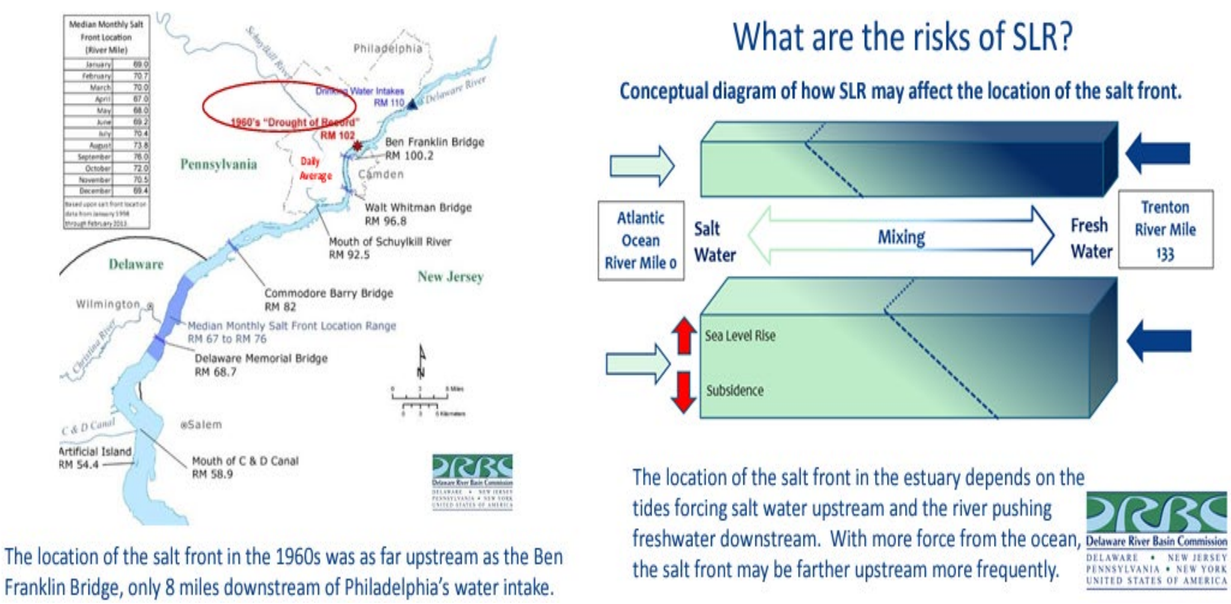

Figure 3.12 Conceptual Impacts of Sea Level Rise on the Delaware River Salt Front (DRBC).

If sea-level rise and/or the low flow effects of drought intensify, the FFMP may need to be modified. If modifications are considered, it is important to evaluate all of the drought management procedures to ensure that the tradeoffs between upper and lower basin water supplies, ecologic and recreational needs, and saltwater are thoroughly understood.

THREATS TO OTHER SURFACE WATER SUPPLY INTAKES

As with the Delaware River salt front, other surface water systems may be vulnerable to sea-level rise. One example is the Forge Pond intake of Brick Township Municipal Utility Authority (BTMUA), on the Metedeconk River in Ocean County. With an increase in sea level of 3 feet (either permanently or through a combination of sea-level rise and storm surge), saline water could penetrate from Barnegat Bay into

and beyond Forge Pond (Figure 3.13). BTMUA has been evaluating options for protection of its public water supply intake. DEP is currently developing a RiverWare model of the water supply system (wells, reservoirs, and intakes) that will be incorporated into the larger New Jersey Model which can be used to assess impacts to safe yield from modified operations. Note this RiverWare model does not simulate sea-level rise so additional assessment(s) will be needed.

Figure 3.13 Forge Pond Area, (a) Current Sea Level and (b) 3-foot Sea-Level Rise (NJCCRC).

Other Atlantic Ocean/Barnegat Bay systems which could be impacted by sea-level rise include the lower Atlantic City Reservoir and Swimming River Reservoir where sea-level rise and increased flood elevations from storm surges could cause significant problems at the dams. These issues should be further evaluated and monitored over time.

CHANGING PRECIPITATION AND TEMPERATURE PATTERNS

Precipitation across New Jersey has already been impacted by climate change. More precipitation is falling on average over the year, more of that precipitation coming in fewer but larger events, and more variability is occurring over the year and from year-to-year. The effects of these changes on water supply are assessed in the sections below.

POTENTIAL IMPACTS TO SURFACE WATER RESERVOIR SYSTEM SAFE YIELDS

NJGWS staff conducted preliminary research on possible changes to surface water supply reservoir system safe yields and pumping requirements in the Passaic/Hackensack and Raritan systems, all of which have been modeled using the RiverWare software in conformance with DEP Safe Yield Guidance Manual (NJDEP, 2011). Refer to Chapter 2 for details on the systems and definition of safe yield. The model is being expanded to include the Coastal North region systems and similar assessments will be possible when those updates have been completed. The assessment included two components.

First was an assessment of stream flow changes in ten watersheds where human impacts (other than climate change) were limited, to determine whether the flows, averaged over rolling 30-year periods, changed at the annual or monthly levels. In general, annual stream flow are increasing and monthly streams flows appear to have increased somewhat in the fall and early winter (especially October and

December) and decreased somewhat in the late winter and early spring over the periods-of-record (see Figure 3.14). The results are variable across the state, with the north appearing to have more water on an annual basis. For on-stream reservoirs this shift in flows, assuming spring flows are not well-below normal, and demand is not excessive, is not expected to affect safe yields as the systems are designed to fill and spill annually. Use of models, such as the New Jersey RiverWare Model, to forecast seasonal storage using observed conditions can inform decision making and provide DEP additional advanced information to determine if actions are needed.

In theory, the same is true for reservoir pumped storage, where a shift to more pumpable flows in the fall and early winter should offset lower pumpable flows in the late winter and spring. However, since pumped storage systems need to be actively managed to turn pumps on and off at the correct times (and don't simply capture runoff as run-of-river systems do) there is an element of increased water supply risk for these systems. In order to prevent unnecessary risk, reservoir operators and DEP oversight will continue to monitor real-time conditions and decision making, develop climate change adjusted pumping guidance curves, and evaluate the need to modify pumping equipment and permit conditions. Water quality will also be factored into the analyses.

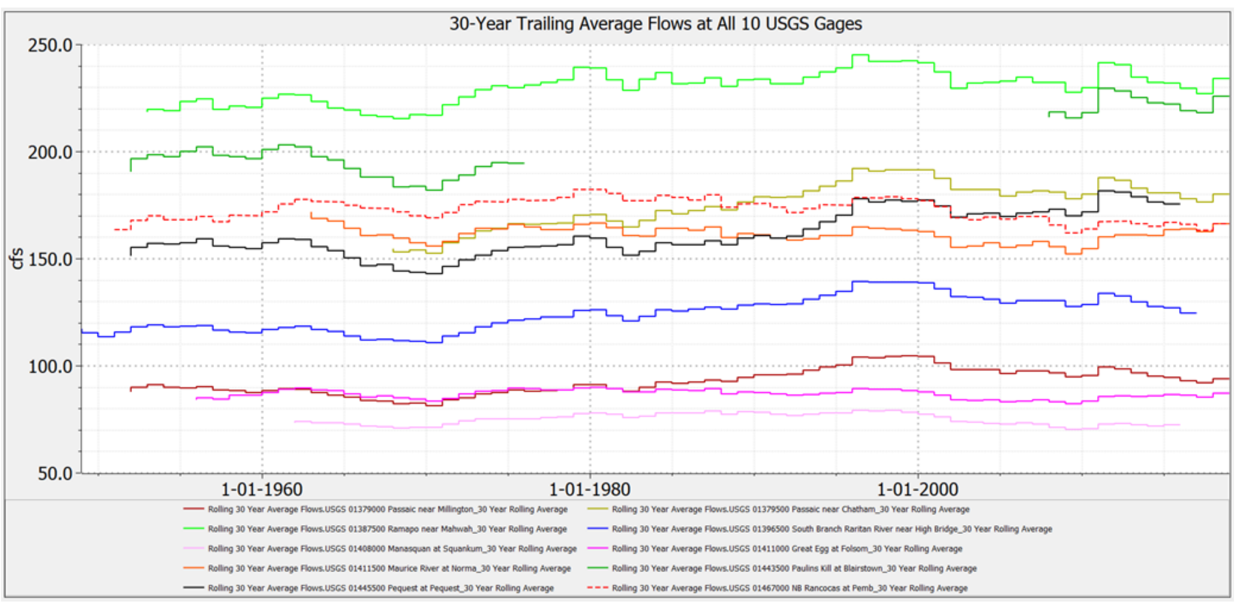

Figure 3.14 30-Year Trailing Average Stream Flows at 10 Selected USGS Gauging Stations (NJDEP).

Second, the models were used to assess how safe yields might change due to future changes in drafts and stream flows related to climate change. The analysis used a theoretical what-if climate change scenario of reduced stream flows and increased reservoir system drafts during the spring, summer, and fall seasons, with variations on reservoir operation and pumping approaches to simulate a range of management options. In general, the assessment showed an increased probability that the reservoir systems reach drought emergency status, with the most significant effects for the Wanaque System and the Hackensack System, which are interlinked through the Wanaque South Pumping Station project. Under the theoretical scenario, the probability of drought status more than doubled, which is a significant impact. However, all systems had adequate storage to meet drafts and did not run out of water. Implementation

of passing flow and effective draft reductions are key tools that proved to be effective management options.

The methods and tools used in this assessment depend heavily on statistical and model analyses of observed hydrologic data and, in some cases, current data is not available. Rapidly developing climate change impacts may not become apparent in observed hydrologic data until significant impacts are already occurring. Improved methods of forecasting future stream flows are needed along with continued funding of existing (or expanded) real-time monitoring networks and analysis of the data collected. Additionally, the model does not yet include all of the state's surface water supply reservoir systems. Future expansions are underway to address these limitations.

As stated at the beginning of this chapter, the analyses conducted as part of this Plan only provide a foundation of the climate change risks to water supply. Additional evaluation needs related to surface water system concerns include:

- the risk of flood events exacerbated by climate change- both precipitation and sea-level rise storm related impacts to infrastructure and treatment (events may induce increased levels of contaminants via New Jersey's numerous superfund sites);
- the emergence of new drought types- such as the quick onset, severe, but short duration 'flash drought' and the probability of a new, more severe longer-term drought of record;
- the apparent increased occurrence of HABs which threaten drinking water operations- both treatment and quantity related impacts;
- increased potential for pathogens in warmer waters; and
- increased dependency on surface water systems in areas of aquifer salinization.

Responses to these events and other unknown issues that will likely arise depend on the continued support and analyses of real-time hydrologic monitoring networks and evaluation of data, the foundation of which is integral to continued support of climate research in identifying and mitigating emerging risks.

EXTREME PRECIPITATION EVENTS AND POTENTIAL IMPACTS TO WATER-SUPPLY INFRASTRUCTURE

More precipitation is falling in larger storm events and thus larger events are becoming more frequent. In other words, what was once considered the "100-year storm", or a storm with a 1% likelihood of occurring on an annual basis, is now an event that occurs more frequently. These larger precipitation events mean more flooding which can impact and disrupt water-supply infrastructure. There are too many examples to list individually, but they cover the gamut of major treatment plants, pump stations, and uncovered finished water reservoirs getting inundated or nearly inundated by flood waters, large and small watermains being washed out, and general disruption of service. Climate change forecasted for the state will only further exacerbate these issues. Many of these issues can be addressed through robust contingency planning and assessment by the system owner and via regulatory programs that acknowledge floods will get worse and occur more frequently.

IMPACTS TO UNCONFINED AQUIFER RECHARGE

Two aspects of surficial aquifer (unconfined groundwater) recharge are climate related. First is the impact on surficial aquifers along the shoreline, where sea level rise can inundate new areas with saltwater. This issue has been discussed above. The second issue is the amount of precipitation that infiltrates beyond the root zone to become groundwater, including aquifer storage. These unconfined groundwaters are critical to direct withdrawals, as baseflow to streams to support overall streamflow and as recharge to underlying confined aquifers.

NJGWS has investigated changes in groundwater infiltration and aquifer recharge in response to climate change through a Land Phase Model (LPM), which "uses the logic of a soil-water budget and readily available data to estimate a variety of outputs, including groundwater recharge (GWR), on a daily timestep" (Domber et al., 2022). This 300-meter grid model builds on the earlier GSR-32 groundwater recharge model (Charles et al., 1993). The LPM provides updated and more detailed outputs for recharge, runoff, simulated evapotranspiration, soil water deficits and other factors than GSR-32, which provided only the average annual normal and drought recharge estimates. GSR-32 results were used in the 1996 Plan to define groundwater availability on a watershed management area basis. As the model is relatively new, the daily results were aggregated up to annual results and calibrated to the GSR-32 results. Only the annual results are utilized in this Plan. DEP is currently working on additional model enhancements that once verified will be used in later analyses.

The first notable result from the LPM is that groundwater recharge has been for the most part rising since 1950 (based on 30-year rolling averages) in both northern and southern New Jersey, with the averages increasing from roughly 12 and 12.5 inches to 14 and 15+ inches per year, respectively. Precipitation is increasing faster than potential evapotranspiration (PET). While these are regional averages and specific watersheds will have varying results, the overall result is increased recharge, which reduces the stresses of water withdrawals from shallow aquifers. The NJGWS study notes that while the model calibrates well to available streamflow data on an annual basis, additions and adjustments will allow for calibration to daily hydrographs, expanding water supply planning applications. A second-generation model is currently in development.

NJGWS also used the LPM to develop nine climate change scenarios using combinations of low, medium, and high changes in temperature and precipitation, through the year 2050. All nine scenarios forecast more groundwater recharge in 2050 than in 1980, statewide, and only two scenarios forecast a decrease from 2020 to 2050, while five scenarios forecast increases and two forecast stable conditions. The results shown in Figure 3.15 are 30-year rolling average groundwater recharge estimates which smooth the year-to-year variability and better shows long-term trends.

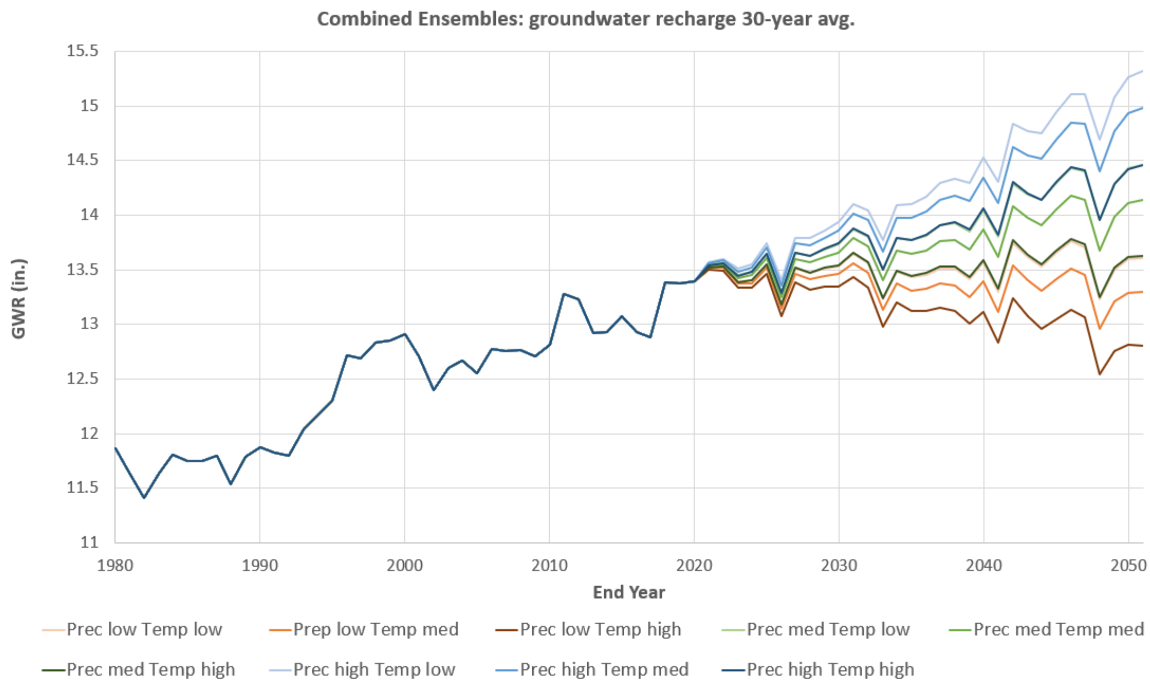

Figure 3.15 Groundwater Recharge Estimates Using 30-Year Rolling Averages (NJGWS).

The scenarios simulating 2021 through 2050 groundwater recharge were based on a combination of three temperature assumptions and three precipitation assumptions for a total of nine possible scenarios. They are low temperature with low, medium, and high precipitation, medium temperature with low, medium and high precipitation, and high temperature with low, medium and high precipitation. In order to account for normal daily, seasonal and yearly variability, the daily time series of temperature and precipitation from 1990 to 2020 was adjusted by the values listed in Table 3.3 and then appended to the 2020 dataset to generate a 2021 through 2050 timeseries for use in the LPM. To account for the observed temperature and precipitation changes which had already occurred over the 1990 to 2020 period, each daily temperature and precipitation adjustment was increased by the fixed 30-yr net value. This adjustment ensured that 1990 data (which then used as the 2021 data) was increased by the change which had already occurred in addition to the per year change assumed. For example, a 1990 temperature value of 15 ^{0}C was increased by 0.558 (0.54+0.018) to estimate a 2021 temperature and a 1991 value of 15 ^{0}C was increased by 0.576 (0.54+0.018+0.18) to estimate a 2022 temperature for the low scenario. The individual year results are shown as 30-year rolling averages in Figure 3.16 for 1920 through 2050.

Table 3.3 Temperature and precipitation changes assumed in the 2050 groundwater recharge analysis.

Scenario	Temperature change		Precipitation Change	
	30-yr Net	Per Year	30-yr Net	Per Year
Low (L)	0.54 ^{0}C	0.018 ^{0}C	4%	0.13%
Medium (M)	0.75 ^{0}C	0.025 ^{0}C	7.5%	0.25%
High (H)	1.11 ^{0}C	0.037 ^{0}C	11%	0.367%

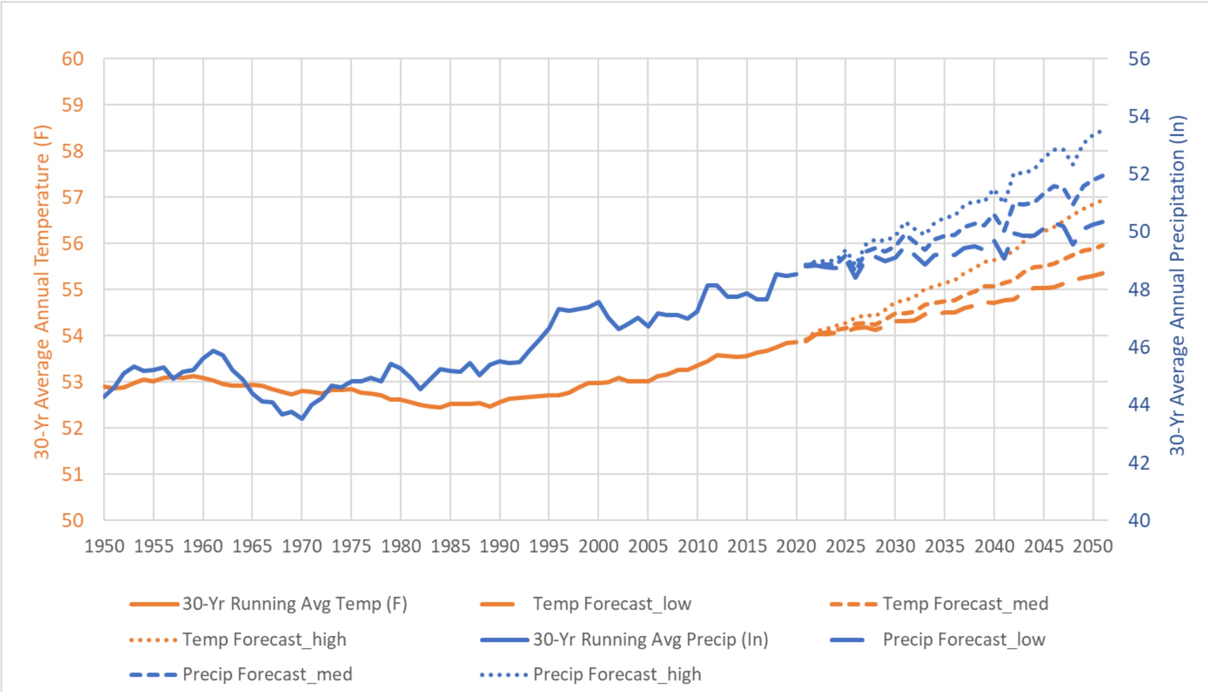

Figure 3.16 30-year rolling average precipitation and temperature data 1920 through 2020 and forecasts for 2021 through 2050. This data was used to generate PET and groundwater recharge (shown in Figure 3.15 above).

IMPACTS TO CONFINED AQUIFER RECHARGE

The primary impact of climate change on confined aquifer recharge relates to groundwater infiltration within the outcrop areas of the confined aquifers, which will be affected in the same manner as for unconfined aquifers. Most confined aquifers outcrop in southwestern New Jersey. Confined aquifers also receive recharge from overlying aquifers, where the same question of aquifer recharge will be of interest.

WATER QUALITY IMPACTS

Climate change has implications for water quality, in all waters but especially in surface waters. Increasing atmospheric temperatures can modify surface water chemistry. The increasing percentage of precipitation that comes during intense rainfall events will tend to increase stormwater flows, pollutant runoff from the land surface, erosion of stream beds (with attendant release of sediment and soil phosphorus), and potential exposure of contaminated soils in riparian areas. As noted in the New Jersey Scientific Report on Climate Change (NJDEP, 2020), increased water temperature, nutrient loads and total dissolved solids increases the potential for lower oxygen levels and an increase in cyanobacteria blooms.

Climate change driven impacts to water quality are not limited to surface water. A 2023 report released by the DEP's Division of Science and Research (Aziz, 2023) conducted an extensive literature review and concluded that the effects of climate change are likely to cause ephemeral and long-term impacts on groundwater quality driven by modifications of hydrogeological processes, including precipitation, groundwater recharge, discharge, storage, and seawater intrusion. These modifications would influence

biogeochemical reactions and the ultimate chemical fate and transport of contaminants and are likely to drive the variability of both anthropogenic and geogenic contaminants.

Initial work here suggests that these water quality changes will not likely reduce total water availability in New Jersey, but they may result in more expensive and intensive needs for source water protection and drinking water treatment and may cause temporary or permanent losses of supply if treatment is not feasible or takes time to install (i.e. limiting supply). Refer to Chapter 2 for a discussion of how new and emerging contaminants can contaminate water supplies and Chapter 5 for additional information on drinking water quality treatment and protection actions.

HARMFUL ALGAL BLOOMS (HABS)

Cyanobacterial blooms (or HABs) are excessive growth of cyanobacteria, which are caused by sunlight, warm temperatures, and increased nutrients. HABs can make people, pets, and wildlife sick from either the cyanobacteria cells themselves or from the cyanotoxins they sometimes produce. With a warming climate, there has been an increase of HABs globally. HABs In New Jersey have been increasing in occurrence since the state's HAB Response program began in 2017, and many have impacted New Jersey's water supply sources. In 2022, there were 65 documented occurrences in New Jersey. Of those, some were in surface waters upstream of water supply intakes, such as Greenwood Lake (upstream of Monksville and Wanaque reservoirs), Spruce Run Reservoir and Carnegie Lake/Millstone River. Though the largest concern with HABs is water quality, they can also have direct impacts to supply when additional supplies are used to attempt to move water or push "HAB water" away from intakes. For example, in the summer 2022, the state had just entered into a drought watch when the Millstone River experienced a severe 9-mile long HAB that threatened a major drinking water intake. Due to the extreme health risk associated with cyanotoxins, the presence of the HAB at the intake could have resulted in a "do not drink" advisory for almost 800,000 people. Therefore, the New Jersey Water Supply Authority released 5 billion gallons of water beyond normal operations to limit the impact of the HAB to the intake. Work has been done and continues to be done to help water systems prepare how to handle a HAB, for example, the development and implementation of cyanotoxin management plans, and work that the Drinking Water Quality Institute is doing to develop recommended standards for cyanotoxins in drinking water.

While surface water quality and HAB response monitoring is ongoing and will continue, a key question will be how to determine the most important causes of water quality problems and identify proactive, source water protection approaches. Ongoing actions such as the new, issued on December 1, 2022 and effective January 1, 2023, NJPDES permits for Municipal Separate Storm Sewer Systems (MS4s), which require development of Watershed Improvement Plans, will help address these issues by reducing nutrient inputs. Proper septic system management is also key, especially for lakefront communities.

DEMAND MODIFICATIONS

At this point, it is difficult to project the impacts of climate change on water demands, as future conditions remain uncertain. However, the state would benefit from expanded research in the following areas:

- Indoor water demands (e.g., bathing, cooking, toilets, clothes washing) are unlikely to change significantly with increased outside temperatures.
- Increased outdoor temperatures will drive higher water demands for lawn and agricultural irrigation, especially given forecasts for more frequent summer dry periods. While these increased demands cannot currently be predicted, one option would be to analyze demands in more southern states along the eastern seaboard, with the assumption that as New Jersey's future summers shift to being more like their current summers, water demands will shift in a similar way.
- Agricultural irrigation demands may change also due to crop selection, toward crops that are more tolerant of higher summer peak temperatures. Likewise, lawn grass seed selections may change to those that are more temperature and drought tolerant, including from cool-season turfgrass species such as Kentucky bluegrass and tall fescue (Grande, 2004; Goatly, 2008) to warm season grasses such as Bermudagrass, which is mentioned as being very well adapted for the hot climates (e.g., Piedmont areas) in Virginia (Goatly, 2008) and Georgia (Waltz, 2020).
- Increased outdoor temperatures may also drive an increase in urban outdoor water demands associated with recreation, street tree maintenance, and heat island reduction. Southwestern states and Mediterranean nations use misting technology to cool public spaces (e.g., school yards, shopping areas) in hot and dry climates; such cooling techniques may find use in New Jersey as summer peak temperatures increase. However, these water demands are not likely to be a major factor in total urban water demands.
- A more localized issue relates to temporary or permanent dislocation of water demands in areas that are damaged by coastal and riverine floods. For example, the New Jersey Shore is experiencing post-Sandy redevelopment, with varying effects on year-round populations. Of the 62 municipalities in Monmouth, Ocean, Atlantic and Cape May counties that lost population between 2010 and 2020, nearly all were coastal communities. Of the 63 municipalities that gained population, most were non-coastal communities but there were some notable coastal and back bay exceptions, such as Red Bank and Absecon (US Census, 2010; US Census, 2020). These population shifts may represent a flux between rental and year-round properties. The question is whether sea level rise will hasten a shift from year-round properties in high-hazard locations, or the loss of developed properties entirely in areas that are badly damaged by coastal storm surge that is exacerbated by sea level rise. It is important to note that sea level rise will increase damages even if coastal storms are no more severe than in the past, as the storm surge will start from a higher base, damaging more properties more severely.

CLIMATE CHANGE INITIATIVES FOR WATER SUPPLY

Climate change has and will continue to impact New Jersey's water supplies in a multitude of short-term and long-term ways. Some may be well understood, and others may be unknown. DEP is committed to increasing its knowledge of climate change impacts on water supplies through continued monitoring, research, and modeling efforts. These efforts will require continuous reevaluation and refinement of future climate conditions and sea levels, and advancement of water supply models.

The concept of stationarity, where the past can be assumed representative of the future, is no longer applicable. While historic droughts and water supply emergencies can still be used as planning scenarios, these events need to be reevaluated in light of climate change and likely projections of future conditions. For example, what will a repeat of the 1960s multi-year drought look like in 2050? Will it be drier or longer or will other factors such as demand increases become important drivers of risk? In order to be prepared for these uncertainties, DEP should continue to utilize an ongoing and adaptive process that monitors, researches, models, implements, and revises. This established practice can be adapted to address future climate conditions.

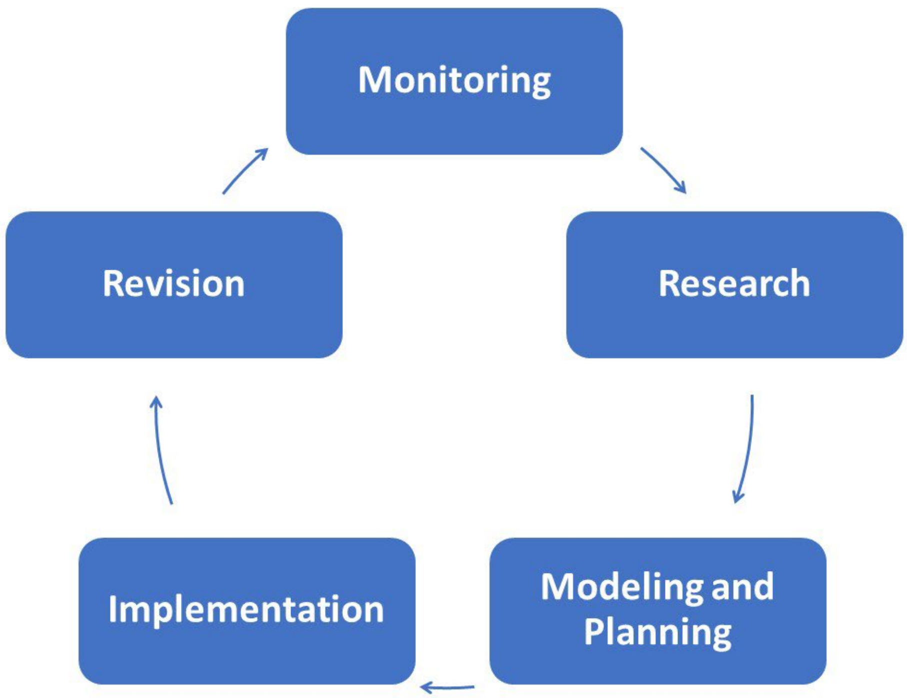

Figure 3.17 DEP overall strategy to address climate change impacts on water supply.

- Monitoring: Real-time or near-real-time climate and hydrologic data needs to be collected and assessed. This information can be used to confirm forecasts and calibrate models in addition to informing day-to-day water supply operations (as well as meet a range of other DEP and stakeholder needs). Monitoring data could also include event or system specific observations so the resulting data could be used to inform next steps (also known as lessons learned).
- Research: Research needs to be conducted and updated to better define what future climate will look like in New Jersey and to specifically define drought and water demands. This could include improved downscaling of global climate model outputs for the New Jersey region.
- Modeling: Models need to be developed, calibrated, and improved to quantify the effects of climate change on water supplies. This could include improved streamflow forecasts to use in reservoir models, advancing the land phase model used for the Plan update, or expanding saltwater intrusion models both in the confined and unconfined aquifers to better assess where impacts to potable aquifer might occur.

- **Implementation**: While no one model or tool is perfect, action typically occurs when data, models and experts agree.
- **Revision**: Periodic reviews and updates of all of these steps should be made so that course corrections can be implemented if needed. That is why this Plan considers future needs well beyond the five-year plan renewal cycle.

SUMMARY

Climate change is here and impacting New Jersey in direct and indirect ways and it will continue to impact the state's water supplies. While it is difficult to pin a specific event solely on climate change, it is apparent that climate change and specifically, sea-level rise along with increases in both temperature and precipitation are contributing to water supply impacts now and moving forward.

A beach located in Ocean City in Cape May County, New Jersey.

The increase of large precipitation events has been observed and is projected to increase during this century. The state has experienced numerous situations where extreme precipitation events have directly impacted water utilities. This list is long and includes events such as the flooding of Passaic Valley Water Commission's New Street uncovered finished water reservoir with untreated runoff resulting from the foot of rain which fell during the remnants of Hurricane Ida, and the repeated 'near misses' at New Jersey American's Raritan Millstone and Canal Road Treatment Plants during Hurricane Irene (2011) and Ida (2021) (both plants had been hardened after Hurricane Floyd caused extensive damage to both facilities in 1999).

Rising temperatures, especially heat waves during the summer can lead to unusually high water demands. When these demands are coupled with aging infrastructure, water mains are stressed and breaks can occur. Each year thousands of water main breaks occur. Most are small and do not cause major outages, but some breaks are very damaging. One example occurred in Newark when a 36-inch main broke in August of 2022, the warmest August in New Jersey from 1895 to 2022 (see Figure 3.1), resulting in the complete loss of pressure in the area served by the Pequannock treatment plant. This caused loss of water at the taps and/or boil water advisories, affecting over 200,000 people in Newark, Belleville, Bloomfield, and Nutley, including four hospitals. The main break was so large that it also resulted in a vehicle being swallowed by a sinkhole at the break site. Another example occurred in October of 2022 when the North Jersey District Water Supply Commission (NJDWSC) experienced an issue with a drainage

valve on one of its major water transmission lines (72-inch diameter) in Nutley, which caused flooding of the roadway and nearby homes. A potential water service loss was narrowly avoided to 539,000 residents. Anecdotally, summer demands for many systems appear to be increasing. However, it is difficult to accurately determine heat is the primary cause. Multiple factors could be implicated, including residential water use changes caused by office and school closures during the Covid-19 pandemic and the regionalization of supplies due to source contamination.

Sea-level rise coupled with warming air and ocean temperatures increases the likelihood and severity of Hurricanes, Nor'easters, and other ocean driven events. Super Storm Sandy caused major damage to water supply infrastructure- primarily to finished water networks. The storm hit New Jersey in late October bringing with it a large storm surge which damaged critical electrical infrastructure in turn impacting utility’s ability to treat and purvey water through the event. While it is difficult to predict exactly where and when these types of events may occur, it is vital for water systems to keep emergency management plans up to date and perform regular testing and maintenance on all interconnections. In the wake of Sandy and other recent adverse weather events, the DEP developed new guidance to ensure that critical repairs, reconstruction, new facilities, and operation/maintenance enhanced resilience of critical infrastructure. The documents address Auxiliary Power, Flood Protection, Emergency Response/Planning and Asset Management. These documents and guidance protocols can be found at the DEP Asset Management website. In addition, communication between DEP, State and Federal disaster relief groups and water supply systems will be integral in these situations.

The initial assessments conducted as part of this Plan are preliminary and do not address all the known water supply issues related to climate change. Those that were conducted suggest that, from a statewide annual average perspective, climate change has resulted in increasing available water for New Jersey. This assumes that the climate forecasts used in the assessments and water resource models are reasonably accurate, demands remain approximately stable, water quality impacts are manageable, and existing infrastructure and sources are maintained. Droughts will continue to occur and may worsen, extreme precipitation events will periodically threaten critical water supply infrastructure, and rising sea-levels will threaten low lying areas and water supply infrastructure.

At this time, it appears that sea level rise impacts will be felt most notably in unconfined aquifers near the current shoreline, inundating both recharge areas and existing wells. The outcrop areas of confined aquifers are likewise at risk in these areas, but the deeply confined portions of these aquifers off the Atlantic coastline, that are not already dealing with saltwater problems, are unlikely to see any significant new risk.

The inland unconfined aquifers have been experiencing increased recharge overall, however that trend may reverse if temperature driven evapotranspiration exceeds increased recharge. These unconfined aquifers are critical supplies for direct withdrawals and for flow to surface waters, as most annual average surface water flows are dependent on the movement of groundwater to streams (base flow) in all but the most intensively developed areas. Unlike surface waters, monitoring of groundwater at a regional scale is difficult. This issue will need a directed research approach to assess ongoing changes.

Safe yields of surface water reservoir systems are not anticipated to be substantially affected by climate change over the duration of this Plan according to current, preliminary modeling analysis conducted to date. Pumped storage reservoirs systems are likely to be most sensitive to changes in the magnitude and timing of streamflow. Further research on potential streamflow changes will be important for improved modeling of future scenarios. While the surface water reservoir systems are expected to have a sufficient volume of water, water quality degradation from increased mobilization of pollutants from more intense rainfall events is expected to impact water supplies. Additionally, combinations of events, aka black swan type events, where multiple limitations or stresses occur simultaneously are possible and can severely limit supplies.

It is critical to recognize that:

- This Plan and its recommendations benefit from the availability of sound and reliable climate change science.
- Though current models cannot predict specific conditions in a specific season in the future, further science and research is expected to improve the accuracy and availability of such tools.
- This Plan's water availability impact evaluations were preliminary and need to be continued and enhanced to confirm findings.
- Normal and severe dry and wet events will still occur, floods are likely to be worse, and infrastructure needs to be maintained and/or hardened to withstand these events.
- Raw and finished water transfers will still be needed.
- More research is needed to characterize future drought frequency, duration, and severity, with increased occurrence of flash drought-like events likely.
- Existing saltwater problem areas still need to be assessed and actively managed.
- Water quality impacts (e.g. HABs) were not quantified but are anticipated and need to be evaluated. The effects on supplies could be significant.
- Sea-level rise will impact unconfined potable aquifers and outcrop areas, and will inundate wells and related infrastructure. Infrastructure hardening or relocation is likely to be needed.
- Saltwater will move further upriver and more often potentially impacting lower elevation dams, intakes and reservoirs.
- Future demands are likely to change in response to a changing climate (e.g. longer growing seasons or hotter summers).
- Laws, regulations, and policies and procedures will need to be updated more frequently to address the evolving science.

In summary, climate change has already impacted the state and its water supplies, and it will continue to impact the state in new and unique ways. While the initial assessments conducted as part of this Plan suggest that the state's water supply quantity is adequate to meet needs on a whole, there is more work that needs to be conducted to ensure that this outcome is achieved. In addition to the immediate policy and regulatory actions identified, modeling capabilities for forecasting long-term impacts must be augmented, source water protection to prevent or mitigate increased water quality problems such as HABs must be improved, and climate change-water supply assessments must be refined and expanded.

Two specific areas DEP intends to target related to climate change include:

- continued evaluation and monitoring of climate change implications for statewide water availability and demand as the science of climate change impacts on water resources and available data evolves in the future (i.e. use updated sea level rise estimates, improved water availability models, and longer forecast periods); and
- further analysis of data gaps, uncertainties, and topics requiring further investigation identified in this chapter. Examples of potential topics for further analysis include:
    - the limitations of downscaling to consider more localized water supply impacts over shorter-time scales (i.e. weekly, monthly, seasonally);
    - the need for periodic monitoring and reassessment to confirm that sea level rise over the next 50 and 100 years does not substantially exacerbate the risk of the movement of the saltwater interface; and
    - the need for further monitoring analyses by DEP oversight and reservoir operators to determine optimal approaches for operating pumped reservoir storage systems in response to climate change.

CHAPTER 4: STATEWIDE WATER DEMANDS AND BALANCES

TABLE OF CONTENTS

OVERVIEW

New Jersey withdraws an average of 750 billion gallons of fresh water each year, based on 2016-2020 data. About 70 percent of total water withdrawals come from surface water. This water supports a variety of uses -- potable supply, power generation, commercial/industrial/mining, and both agricultural and non-agricultural irrigation. Some of this water is returned to its original source, but some does not, going to either consumptive or depletive losses.[1]

Irrigation at Specca Farm in Bordentown, New Jersey. Agricultural water use is almost entirely consumptive for most crops during the growing season.

Each use sector consumes a different percentage of water, and this percentage varies from summer to winter and between types of uses. For example, power generation using once-through cooling processes consumes only a very small percentage of water it uses, while evaporative cooling processes use far less water but evaporate most of it. Agricultural use in the growing season consumes almost all of the water it withdraws, though water used for cranberry harvesting is mostly non-consumptive.

Water withdrawals can also result in the transfer of water from one place to another (known as a depletive use since it is depleted from the original water resource); for example, wastewater discharges to fresh waters are often not to the source surface water or aquifer; what is a depletive water loss to one water resource may be an additional supply in another and is tracked as such. However, roughly 70 percent of all treated wastewater effluent in New Jersey is discharged to saline waters (e.g., oceans, bays, estuaries), making it unavailable for further use. The combination of consumptive and depletive water uses has a major impact on the state's water resources.

Water withdrawals and use vary both spatially and temporally across the State. Power generation uses of surface water declined sharply from 2005 to 2011 as electricity generation shifted from coal fire powered

[1] Consumptive loss means water is removed from the water supply resource (ground or surface water), used, and lost to the atmosphere, generally through evapotranspiration. Depletive loss means the withdrawal of water from a water supply resource where the water, once used, is not discharged to the same water supply resource in such a manner as to be useable within the same watershed (e.g., exported out of the watershed); it may be available for use elsewhere in the state if discharged to fresh waters. These terms are used throughout this NJSWSP.

plants to natural gas and renewable energy and more efficient cooling systems were implemented. (Note: coal-fired power plants are no longer active in New Jersey). Statewide total water withdrawals (excluding power generation) have decreased by an average of 3.8 billion gallons per year (bgy) over the 30-year study period (1990-2020). The decline is due primarily to reduced demands in the commercial/industry/mining sectors. At the same time, potable supply withdrawals have varied from 400 to 450 bgy through the entire period with no discernible trend, despite a major increase in population (from 7.7 million in 1990 to 9.3 million in 2020, a 20% increase).

Consumptive use related to water supply withdrawals, however, have increased. The consumptive use trend reflects, in part, increased potable supply uses (from public water systems and private wells) for water-intensive recreational uses and lawn/garden irrigation, and for agricultural irrigation practices. Total consumptive losses varied between 55.6 and 98.5 bgy for the study period with over half of the losses coming from the potable supply sector alone. Consumptive losses are rising at a rate of slightly more than half a billion gallons per year (this excludes trends associated with the power generation use sector).

Within any sub-region of the State, different and even converse trends may be observed. A larger amount of water withdrawal can be sustained without adverse environmental impacts if the water remains in useable form within the original source watershed and/or there is a significant volume of available water. On the other hand, a smaller amount of water loss in places with limited water availability may be unsustainable. Chapter 2 discusses the approach used to estimate available water. This chapter discusses both water demands and how they affect net water availability for the three categories of water resources.

New water data are continually submitted to DEP; the related water demand forecasts and availability can change in response to the new data. As such, DEP routinely updates its water data, periodically revises its water availability and forecast analyses, review the results, and incorporate policy and/or regulatory changes, if necessary, in response to the continually evolving information. This important work informs both annual monitoring of water demands throughout the state and future updates to the Plan.

NEW JERSEY WATER SOURCES

There is one water cycle, but for the sake of planning and accounting purposes, water is assigned to one of three sources: surface water, unconfined groundwater and confined groundwater. The DEP's planning and permitting authority is on fresh (not saline) water, however as water resources become limited and sea-level rise continues to impact sources that were previously fresh, some saline diversions, however minimal, are included here. It is also important to note that there are some users of saline water such as the nuclear power generating and aquaculture facilities, but they are not the focus of this Plan, and their volumes are not accounted for in the following discussions.

DATA SOURCES

New Jersey has a long history of monitoring water withdrawals and use. The current monitoring and reporting system stems from the 1981 Water Supply Management Act and corresponding Water Supply Allocation Permits rules (N.J.A.C. 7:19) and the Agricultural, Aquacultural, and Horticultural Water Usage Certification rules (N.J.A.C. 7:20A). The Water Allocation regulations require quarterly water use reporting for monthly water withdrawals with sources having the pump capacity to withdraw 100,000 gallons per day (gpd) or more of fresh water, or 50,000 gpd in the Highlands Preservation Area. The agricultural regulations require annual reporting of monthly water withdrawals for sources that have the pump capacity to withdraw 100,000 gallons per day (gpd) or more of fresh water.

The water use characterization summarized in this chapter originates from the withdrawal data reported by water allocation permittees as well as agricultural water usage certification and water usage registration holders. It also includes supplemental data such as private domestic well withdrawal estimates. Sources include:

- Water Allocation Permits, Water Use Registrations, Agricultural Water Usage Certifications, Agricultural Water Usage Registrations;
- Safe Drinking Water public community systems and bulk transfer of potable water between systems;
- NJ Pollutant Discharge Elimination System sanitary sewer surface water and groundwater (>2,000 gpd) discharges; and
- private domestic well withdrawal estimates by census block group with region-specific per capita water use rates and household density information developed from US Census, well permit datasets, and DEP commissioned reports.

The data and analyses in this chapter are taken from information in the New Jersey Water-Transfer Data Model (also referred to as NJWaTr or NJ Water). This database contains information on sites of water withdrawal, use, and discharge quantities associated with each site on a monthly basis, and linkages between the sites. The NJWaTr water use characterization data presented here cover the period 1990 through 2020 and represents the best data available to assess water use and estimate water availability in New Jersey (Tessler, 2003). Note that the data used in the work may differ from the DEP's regulatory water use datasets.

DATA UNCERTAINTIES

New Jersey has a robust data system for water withdrawals, based on decades of record keeping. However, as with every type of measurement, there are inherent uncertainties in measuring water withdrawals, depending on the type of use and whether the withdrawals are measured by calibrated meters, by estimates based on pump capacity, or by indirect methods. The uncertainties may range from minor to significant. Where a water resource is identified as having a major surplus of net available water, uncertainties in withdrawal measurement are unlikely to be a major factor. However, where a major water stress is identified, having more accurate withdrawal data will be critical.

Water Allocation Withdrawals: Non-agricultural withdrawals in water allocation permits are required to provide monthly data on withdrawals. These data are based on meter readings at the water source, and

they are considered accurate within the limits of the meters, assuming periodic calibration and proper recording and reporting. The monthly data are periodically reviewed for discrepancies that indicate a data problem. Another potential issue is whether some water withdrawals that should have water allocation permits are not yet regulated. Again, this issue is unlikely to create a significant data problem statewide or regionally but may be of concern in stressed areas, as missing withdrawals can make a situation look better than it is. Finally, industrial and commercial demands can vary significantly from year to year, based on changes in manufacturing processes, mining operations, and seasonal recreational demands. These shifts can complicate demand analyses and forecasts.

Agricultural Withdrawals: Several issues exist regarding agricultural withdrawals. First, agricultural withdrawals are heavily influenced by crop selection, soils, precipitation levels and patterns, and temperature levels and patterns, all of which can vary greatly from year to year, season to season. These variables make analysis of water resource impacts and projections of future demands difficult. The second issue is data uncertainty. Current DEP regulations only require that agricultural withdrawals under agricultural water usage certifications be documented and reported. When meters are not employed by the certification holder to measure water withdrawal, regulations require the use of rated pump capacity multiplied by the hours of operation. Recent research by DEP and partners has compared these values against meter readings through a voluntary field trial. The general result is that the normal method (pump capacity multiplied by hours of operation) tends to exceed meter readings, especially for higher volumes (more than 2 million gallons per month). The study did not analyze causality, but the results might reflect differences between pump capacity ratings (based on free-flowing water) versus reality, where the pump is pushing water through a distribution system, which could slow the flow of water. While further tests would be useful, the research indicates that available reports on major agricultural withdrawals may overstate actual flows.

Another potential complication with agricultural withdrawals is understanding the extent to which irrigation water is returned to either the same or another water resource. Irrigation ideally provides only sufficient water to support plant growth, but some irrigation systems may result in water infiltration past the root zone, constituting groundwater recharge. The NJ Water Tracking System estimates the percentage of agricultural withdrawals that are lost to evapotranspiration, but these are general assumptions, not site-specific measurements, due to the high cost of such field research.

Water Returns: Not all potable water withdrawals reach customers. Inevitably, each public community water system (PCWS) will have some water losses from pipelines, with some of 25% or more. In some locations, these losses may result in groundwater recharge to aquifers, while in others, the water is lost to public use entirely. It is not feasible to measure the extent to which PCWS water losses result in recharge. In most areas this will not be a major factor, but it could be in some deficit regions. However, while unaccounted-for water may be reported to be between 15-25% in some cases, this calculation does not distinguish between real losses (i.e. water lost due to leakage) or apparent losses (i.e. water lost due to billing, metering, or systemic data handling errors). In its proposed rulemaking to codify the Water Quality Accountability Act (WQAA), the DEP intends to incorporate requirements for applicable PCWS to conduct and submit an annual AWWA Water Loss Audit. Once the DEP begins to collect and analyze this data, it would be easier to characterize the extent to which different regions may be experiencing returns to

aquifers due to leakage, or other causes. 70% of all treated wastewater effluent is discharged to saline waters, representing a 100% consumptive/depletive water use.

Self-supplied residential household and irrigation demands: New Jersey has many households (roughly 10% of the total population) with private domestic wells to meet all potable water demands, including outdoor uses. No metered data are available for these sources, therefore, a model is used to estimates total demands from private domestic wells based on well permitting and drilling records maintained by DEP, the population not residing within PCWS service areas, multiplied by an average per household demand. Additionally, an unknown number of additional households have private irrigation wells, while the indoor uses are supplied by a PCWS. Statewide withdrawals for this situation are likely very small but locally they may be measurable. As with agricultural withdrawals, the underlying data uncertainties will not be problematic where water resources are not stressed or where private wells represent a small portion of total withdrawals.

SOURCES OF WATER

New Jersey withdraws fresh water from one of three sources: surface water, and both confined and unconfined aquifers. Figure 4.1 shows annual total surface water, unconfined aquifer and confined aquifer withdrawals for the period 1900-2020. On average, New Jersey obtains 8% of its water from confined aquifers, 18% from unconfined aquifers, and 74% from surface water sources. Total withdrawals for all purposes have declined more than 25% from 1990 to 2020; most of the decline is surface water. Figure 4.5a below also shows the proportion of water sources geographically across New Jersey's five water regions.

The summary of water withdrawals by source is complicated by two factors. First, surface water is stored in reservoirs when incoming surface water flows are high during wet periods; storage levels decline when drier conditions prevail. These withdrawals typically do not lower streamflows excessively because DEP requires minimum stream passing flows (discharges from the dam to the river) to be maintained. Second, unconfined aquifers are hydraulically connected to the streams. Water may flow into the streams (called baseflow) or from the stream (recharging the groundwater but decreasing streamflow) depending on relative water levels. These factors complicate estimating how much water is available for use now and in the future. This issue is discussed in more detail in Chapter 2.

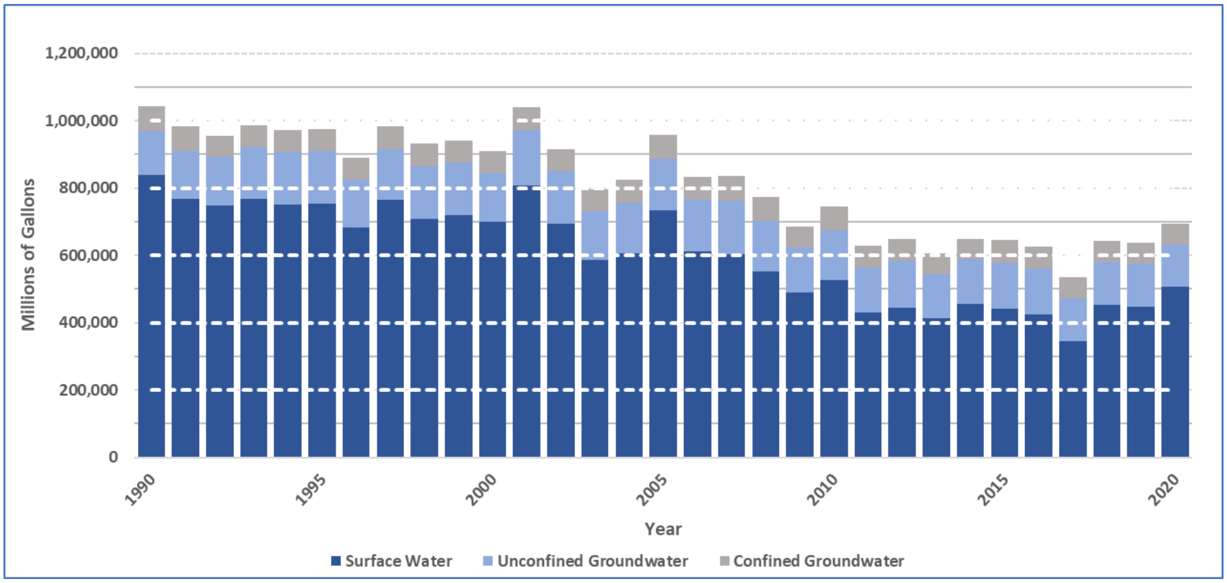

Figure 4.1 Annual Statewide Source of Water Withdrawal, 1990-2020.

WATER WITHDRAWALS AND USE

Reported water withdrawals do not necessarily equal water uses so they are treated separately. The main example of this is water that is withdrawn to fill up a water supply reservoir, but which is not diverted to a potable water public supply treatment plant and then customers until later when it is actually needed. In most other cases, such as water withdrawn from a well or intake for irrigation purposes, it is used immediately so withdrawal will equal use (at least on the monthly timescale that data is reported/estimated on in the state). These differences are typically observed when data is compared at the site scale, but one example of this difference in the Plan is in the reported totals in Figures 4.5a and 4.5b for the Passaic water region.

STATEWIDE WITHDRAWALS

Figures 4.2, 4.3 and Table 4.1 show annual withdrawal volumes from 1990 - 2020 by water use sector. As shown in Figure 4.1, annual water withdrawals in New Jersey peaked at over one trillion gallons in 1990, but overall withdrawals have decreased in the last few years to 700 billion gallons in 2020. The changes are partially the result of a shift by power generators to natural-gas powered stations (which use less water than coal-powered stations). This shift is a function of economic forces and is likely to remain as additional energy comes from renewable sources; the last coal-fired facility in New Jersey closed in 2022. The conversion to renewable energy sources may require the temporary (construction dewatering, etc.) or long-term use of water but it is anticipated that total water use will still be significantly less.

Withdrawals for power generation, attributable to only fourteen individual users in 2020,[2] represent approximately one-half of all water used statewide in some years, primarily through 2005. Since most of this type of water use is neither depletive nor consumptive (in other words, it is a non-consumptive use that is not transferred from the source watershed), water used for power generation is sometimes removed from the withdrawal summaries, such as in Figure 4.3 and 4.8.

Agricultural water withdrawals summarized here and throughout this Plan include traditional agricultural uses like irrigation of crops, plants and animals, frost protection, and cranberry harvesting, as well as other horticultural uses as identified in the Agricultural, Aquacultural and Horticultural Water Usage Certification Rules (N.J.A.C. 7:20A). New Jersey law (N.J.S.A. 58:1A-1 et seq.) specifically exempts saltwater diversions from DEP regulation, therefore aquacultural activities in salt water or any saltwater diversion used for cooling or other purposes is not included in these summaries (see N.J.A.C. 7:19 – 1.4). As sea-levels rise, climate changes and water treatment technologies improve, New Jersey may need to revisit this exemption.

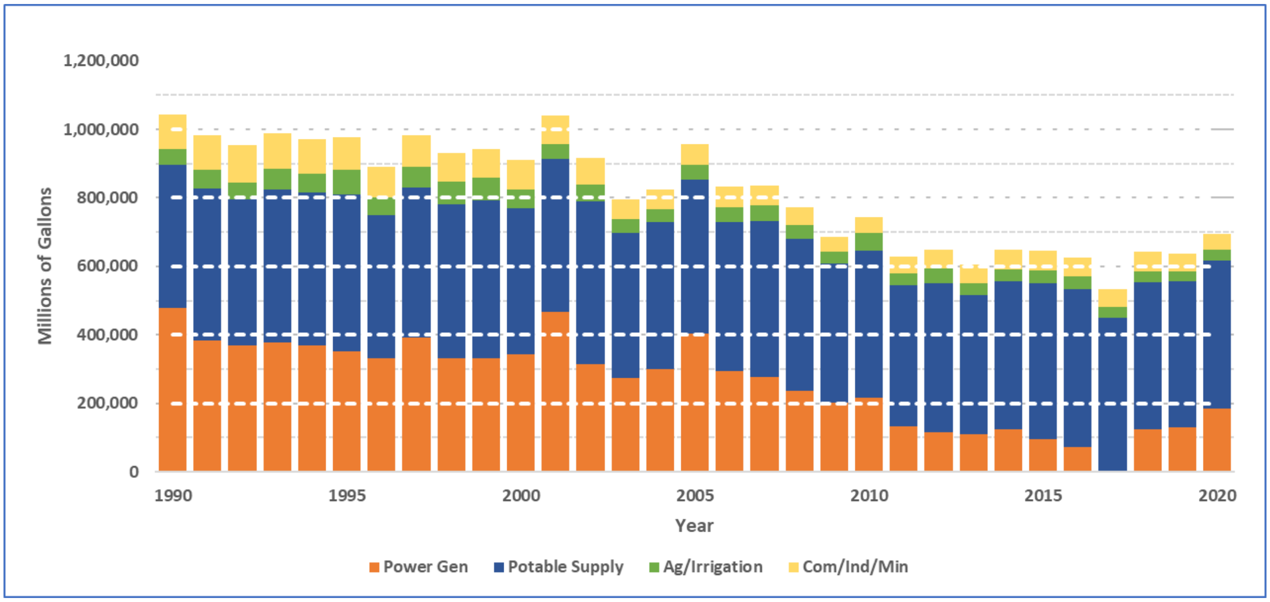

Figure 4.2 Water Withdrawals by Use Sector, 1990-2020.

[2] In 2020, two of the 14 power generation users are specifically hydropower generators. These two hydropower users represent over 90% of the total power generation withdrawal. The withdrawal, use and discharge occur at essentially the same location with minimal consumptive loss associated with it.

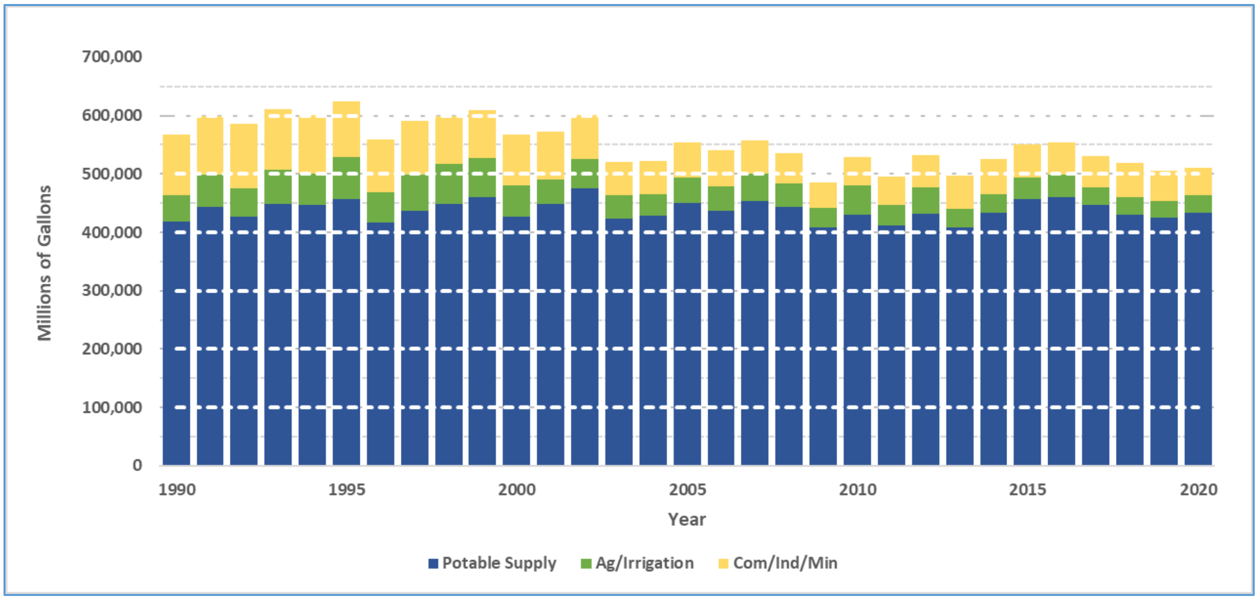

Figure 4.3 Water Withdrawals by Use Sector, 1990-2020, excluding power generation.

Potable water withdrawals include both self-supplied potable sources and withdrawals by public community water systems. These public community water systems often have a mix of residential, industrial, commercial and irrigation use components (especially for larger systems) which vary between water systems. All withdrawals by public community water systems are considered potable supply because many systems do not have the ability to distinguish the exact use. DEP began requiring an estimate of residential demands under the Water Quality Accountability Act, which will allow for better differentiation of water demands in future iterations of this Plan. As Figure 4.4 shows, of the 220 PCWS reporting this value (as of September 16, 2022), 77 reported that residential demands were 90% or more of their total demands and 151 reported values of 70% or more. Only 16 PCWS reported that residential demands were less than 50% of total billed demands. Most small PCWS were created to serve primarily residential areas and would tend to have the highest percentages of residential demand. Large PCWS serve a mix of residential, industrial, commercial, and public customers and therefore will have somewhat lower percentages of residential demands. For example, Newark, Passaic Valley Water Commission and Camden City all reported values between 40% and 50% residential demand.

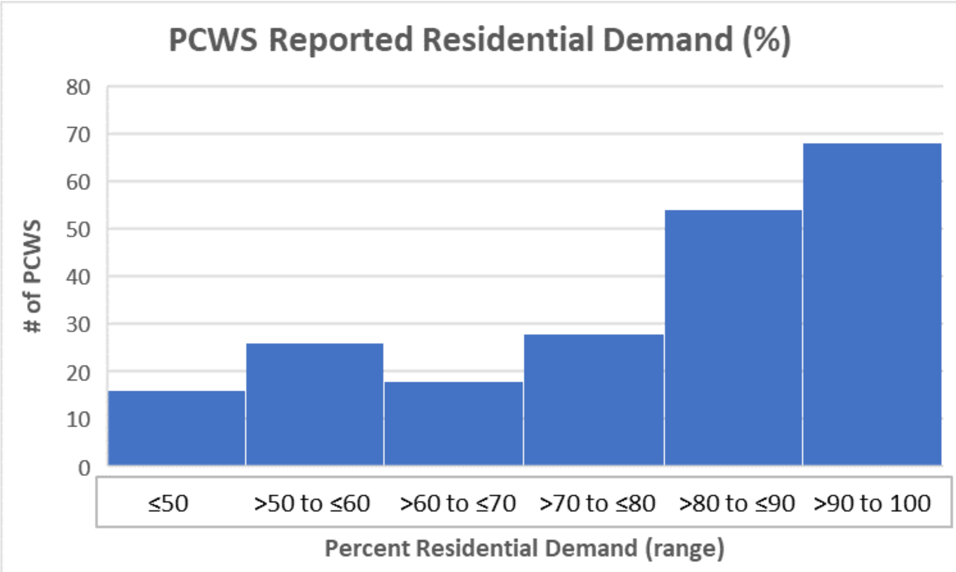

Figure 4.4 Residential Demands as a Percentage of Total PCWS Demands.

Statewide water withdrawals vary from year to year and from sector to sector (Figures 4.5 and 4.6, Table 4.1) primarily in response to weather conditions but also due to changes in economics and public policies. Annual withdrawals of water, excluding power generation, ranged from 485 billion gallons (bg) in 2009 to 624 bg in 1995, with an average of 553 bg. Potable supply accounted for the majority of non-power generation use, 79% on average. Combined commercial/industrial/mining use made up another 13%, while agriculture and irrigation are 8% of average use.

Table 4.1 Annual Water Withdrawals by Water Use Sector, in millions of gallons

Water Use Sector								
Year	Agricultural	Commercial	Industrial	Irrigation	Mining	Potable Supply	Power Generation	Total Withdrawal
1990	44,658	459	75,307	2,090	26,521	417,652	477,355	1,044,043
1991	52,135	534	70,250	3,033	29,418	443,656	383,202	982,229
1992	45,933	497	70,267	2,543	39,698	427,572	367,699	954,209
1993	54,193	620	70,485	3,896	32,684	448,997	376,575	987,450
1994	49,390	557	63,029	3,384	38,273	446,933	369,511	971,077
1995	67,851	596	52,250	4,155	41,747	457,552	351,934	976,086
1996	48,438	617	51,937	2,684	38,061	416,810	331,985	890,532
1997	58,718	473	47,857	4,343	43,881	436,202	392,357	983,832
1998	62,981	554	46,722	4,772	36,248	448,631	332,256	932,163
1999	62,033	300	46,425	4,490	34,785	460,598	333,018	941,649
2000	49,696	525	50,075	3,655	36,036	427,154	343,483	910,623
2001	35,860	554	46,115	6,506	35,925	448,296	466,088	1,039,343
2002	45,912	492	36,080	4,352	39,030	475,129	314,050	915,046

Water Use Sector								
Year	Agricultural	Commercial	Industrial	Irrigation	Mining	Potable Supply	Power Generation	Total Withdrawal
2003	36,044	508	42,090	4,418	13,484	423,197	275,039	794,779
2004	31,312	569	42,558	5,107	13,889	429,117	300,830	823,382
2005	37,033	608	43,780	7,005	14,681	450,430	402,970	956,508
2006	36,723	581	39,179	6,097	20,830	436,550	293,733	833,692
2007	38,794	431	38,859	6,944	18,164	454,341	277,490	835,024
2008	34,660	429	36,211	6,297	14,712	443,447	236,396	772,151
2009	28,364	477	33,081	4,203	10,356	408,918	200,603	686,001
2010	44,123	359	30,512	7,103	16,508	429,971	215,230	743,806
2011	29,274	401	29,368	5,297	19,511	412,231	131,597	627,679
2012	38,072	472	32,420	5,773	22,748	432,534	116,950	648,969
2013	26,627	471	33,230	5,359	23,234	408,749	108,607	606,277
2014	27,610	387	32,845	5,432	25,518	433,059	124,415	649,266
2015	30,097	243	34,780	6,812	21,263	457,430	94,101	644,725
2016	31,554	496	36,007	6,604	18,462	460,683	71,150	624,957
2017	24,601	472	33,398	5,027	19,604	446,877	4,171	534,150
2018	25,376	493	36,332	4,524	21,766	430,898	123,273	642,662
2019	23,691	329	37,143	5,043	15,077	424,634	131,295	637,212
2020	24,734	526	35,876	5,199	11,442	433,324	183,951	695,051

Figure 4.5a shows the average annual reliance on each source of water withdrawn in New Jersey's five Water Regions, based on data from 2016 to 2020. Water Regions are compiled from entire Watershed Management Areas, which in turn are compiled from HUC11s. The size of the pie chart is proportional to the volume of the withdrawal. The data show the regional variations in source of water and in water demands. The amount of water withdrawn does not necessarily equal the amount of water immediately used. This is particularly true for the potable supply sector where water may be withdrawn one month, stored, and then used several months later. One example is pumped water (sometimes referred to as pumped storage) used to fill a reservoir. In this case water is withdrawn from a river and pumped into a reservoir, where it is stored until it is directly or indirectly withdrawn at a later time into the potable water treatment plant. From here the water is treated and sent into the distribution system for use by its customers. Three reservoirs are almost entirely dependent on pumped storage: Round Valley, Manasquan and Brick Township, while the Wanaque and Oradell reservoirs are augmented by pumped storage. Managed Aquifer Recharge (MAR, aka Aquifer Storage and Recovery) is another example of delayed use, where water is temporarily stored in an aquifer and later retrieved for use.

Figure 4.5b shows the average annual water use by sector in each of New Jersey's five Water Regions based on data from the 2016 to 2020 period. The size of the pie chart is proportional to the volume of the water used and may be different than the size of the corresponding withdrawal chart, Figure 4.5a. This is

the result of stored potable water withdrawal which are used later and from the movement of water from one water region where it is withdrawn to another water region where it is used.

For both Figures 4.5a and b, the larger circles in Northeast New Jersey (the Passaic Region) reflects the large population; nearly all the water withdrawals are for potable supply (similar to the Raritan Region). The Upper Delaware Region, however, has similar water demands despite its much lower population. Comparison of the two figures shows that a major demand in that region is for power generation, in part related to a pumped storage hydroelectric facility in the region. The Lower Delaware Region also is distinct from the others, with a sizeable share of demands within the Commercial/Industrial/Mining and agricultural sectors.

Water use trends, similar to withdrawal trends, vary from month to month as well as year to year. In New Jersey, water use typically peaks during the summer when outdoor and irrigation/agricultural demands are high. Figure 4.6 shows statewide average monthly use for the 2016-2020 period. February is the month with the lowest average withdrawals, 36.9 billion gallons, and July the greatest, 53.3 billion gallons. (This summary excludes withdrawals for power generation.)

Water withdrawal data, aggregated by HUC 14 and municipality, is available to the public via the New Jersey Water Withdrawal Data Summary Viewer. Withdrawals can be viewed by use group or source type and can be filtered geographically by selecting one or more HUC14s or municipalities.

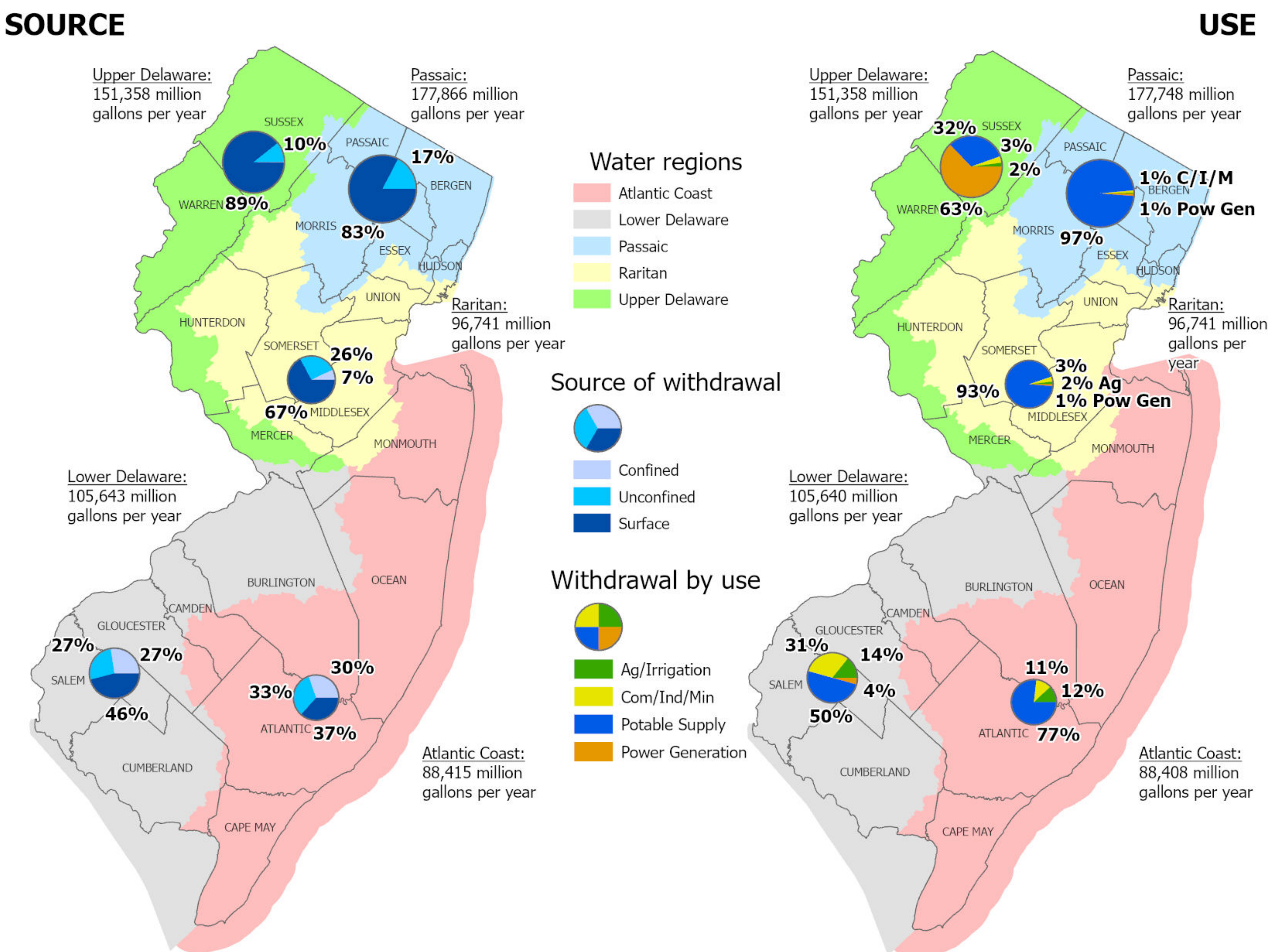

Figure 4.5a Average annual source of water withdrawal, by water region, 2016 - 2020 (millions of gallons).

Figure 4.5b Average annual use of water, by water region, 2016-2020 (millions of gallons).

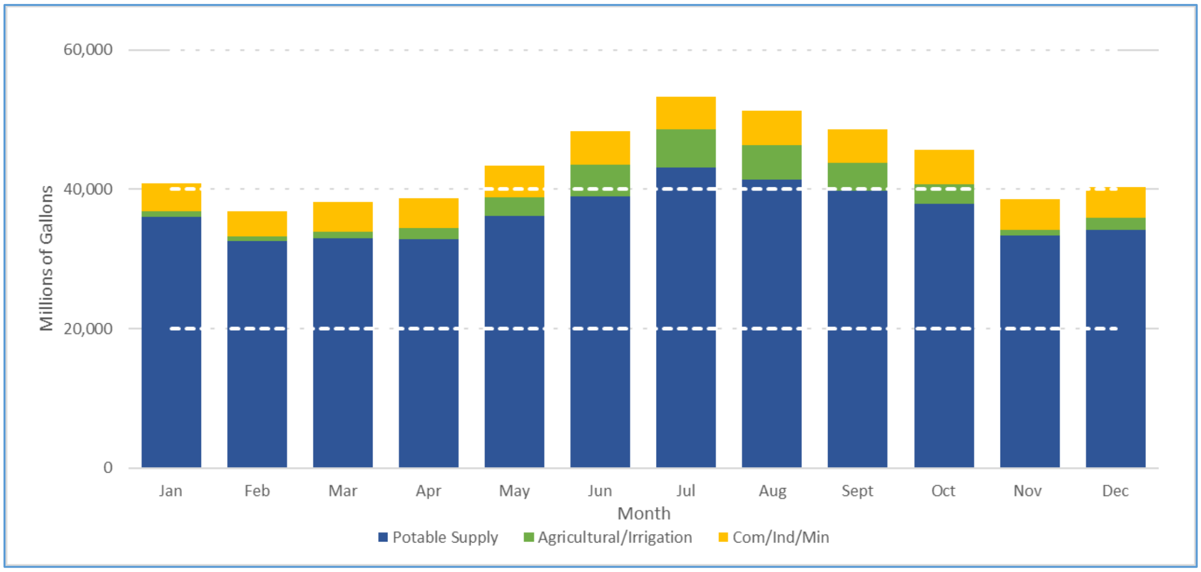

Figure 4.6 Statewide Average Monthly Use by Sector, 2016-2020.

CONSUMPTIVE AND DEPLETIVE USES

Total withdrawal and total use can be somewhat misleading when it comes to determining hydrologic impacts, because not all water use results in a consumptive or depletive loss to the basin; some is returned to the same water resource and is available for new uses. Hydrologic impacts are a function of many site-specific and regional factors and include the consumptive or depletive loss associated with one or more withdrawals, the seasonal withdrawal pattern, and the hydrogeology and water budget of the watershed. Figure 4.6 shows statewide annual consumptive water use by sector for the period 2016 to 2020. Consumptive losses rarely can be directly measured, but rather are based on research results (e.g., for agricultural and non-agricultural irrigation practices), a comparison of water withdrawals to discharges of treated wastewater effluent, and a comparison of growing season and non-growing season demands. While the estimates are based on strong data, regional and local variations may exist in the accuracy of results. Therefore, the estimated consumptive losses need to be used carefully in water availability analyses.

Based on the estimates for the period 1990-2020, consumptive loss associated with potable use has increased on average by about 333 million gallons a year. Consumptive loss due to agricultural and non-agricultural irrigation has increased by 166 million gallons a year. The values in both cases primarily reflect increased irrigation demands for agriculture and landscapes. On the other hand, consumptive loss associated with commercial, industrial, and mining uses has decreased by 150 million gallons a year. The net amounts to an average annual increase in consumptive loss of 349 million gallons a year.

Consumptive use varies from year-to-year based upon temperature, precipitation and changing demand patterns (e.g., agricultural or lawn irrigation practices or population growth), but the general trends observed in Figure 4.7 indicates that consumptive use is generally increasing over the period of record.

Figure 4.8 is a comparison of the estimated statewide non-consumptive and consumptive water use for each water use sector for the period 1990-2020. Note that the y-axis scales on the four subgraphs vary considerably. For example, non-agricultural irrigation is largely consumptive, but the total consumptive use by non-agricultural irrigation is far smaller than that of Potable Supply even though the consumptive portion of public supply use is small percentage wise. Figure 4.9 summarizes total average use over the period 2016-2020 by water use sector, Figure 4.9a and consumptive losses attributable to those user groups in Figure 4.9b. Potable supply total use accounted for 82% of the total use, but 64% of the consumptive loss. Agricultural and non-agricultural irrigation accounted for 7% of the total use, but 30% of the consumptive loss.

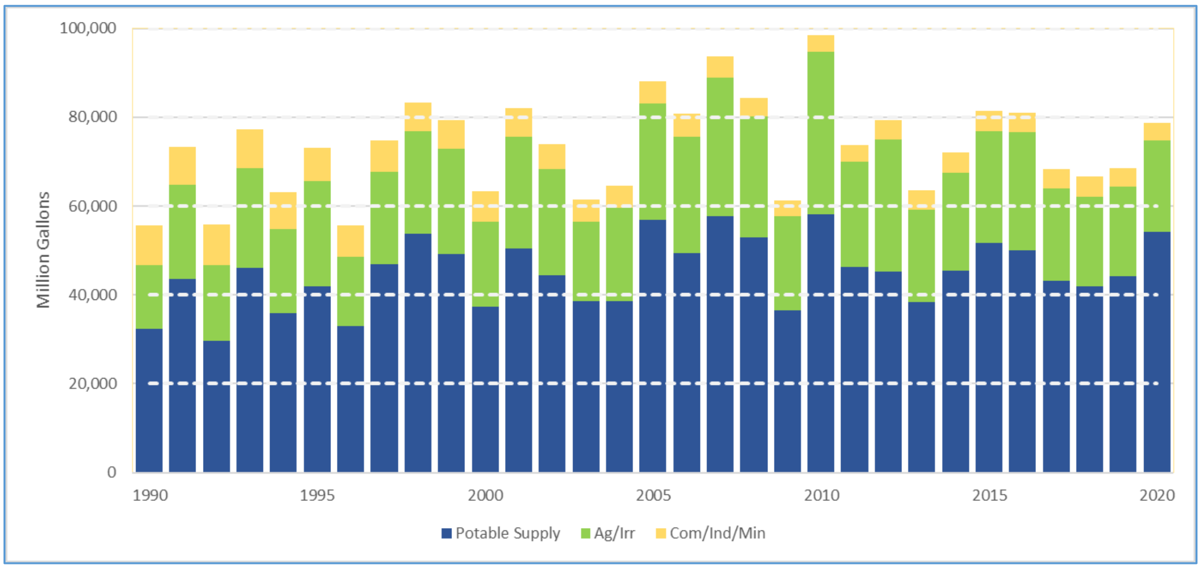

Figure 4.7 Statewide Annual Consumptive Water Loss from All Use Sectors except power generation (1990 – 2020).

Figure 4.8 Statewide Water Withdrawals and Consumptive Use by Water Use Sector, 1990-2020. (Note: The vertical axis scale varies significantly in magnitude between graphs.)

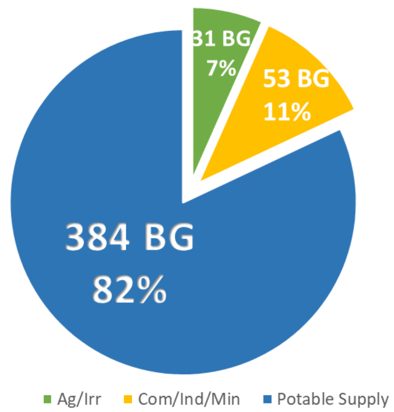

Figure 4.9a Average total water use by sector (billions of gallons and % of total), 2016-2020.

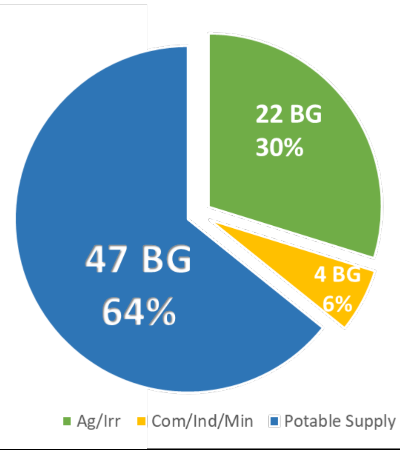

Figure 4.9b Average consumptive losses by sector (billions of gallons and % of total), 2016-2020.

Depletive water uses are more difficult to map, but the NJWaTr database does track the movement of water from its source to its discharge point. In many cases, depletive uses are caused by the movement of water from a reservoir to a distribution system downstream or in another watershed entirely. In other cases, water is withdrawn from aquifers and then discharged to either fresh surface waters or to saline waters. Roughly 70% of all treated wastewater from sewage treatment plants is discharged to saline waters, leaving only 30% discharged to fresh waters where it can be used for ecological support or human purposes. As such, depletive water uses are much larger than consumptive water uses statewide, but the relative importance of consumptive and depletive water uses vary greatly from watershed to watershed.

The robust nature of the NJWaTr database allows for the tracking of water from withdrawal to use and ultimately its return to the natural system. Figure 4.10 combines this data into one Sankey diagram illustrating both the movement and magnitude of water that result as demand is met during an average year in New Jersey.

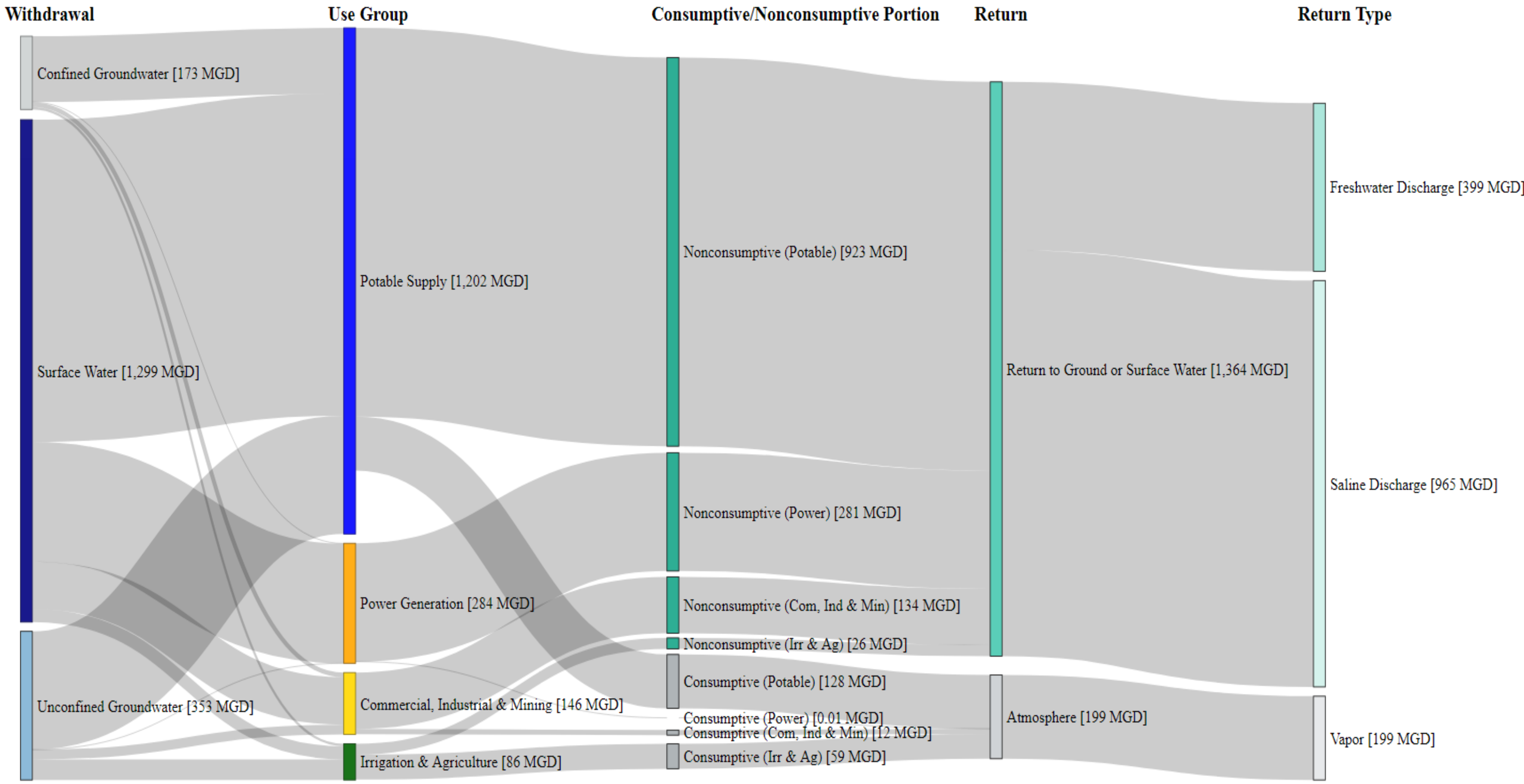

Figure 4.10 Sankey diagram displaying how statewide water withdrawals are distributed by use group and ultimately either returned via discharge or lost to the atmosphere. Displayed data is based on annual average using 2016-2020 and represented in million gallons per day (mgd).

POTABLE SUPPLY USE

Potable supply consists of the water provided by New Jersey's public water systems and individual private wells. Water use by this sector represents 384 bg statewide total and 64% of consumptive use (excluding power generation). Figure 4.11 illustrates monthly statewide potable consumptive and non-consumptive use for the study period. The data show that overall non-consumptive use remains relatively constant, and that year-to-year variability is driven primarily by changes in consumptive water use, primarily driven by outdoor water uses.

Oradell Reservoir managed by Veolia Haworth in Haworth, New Jersey. Reservoirs helps to meet statewide needs for potable supply, which is the most significant water use in New Jersey.

Another important factor associated with potable supply water use is population. According to the U.S. Census Bureau, New Jersey's population increased more than 19.7%, from 7.76 million people in 1990 to 9.29 million in 2020. This increase in population and the associated water demand has been tempered by reductions in non-residential (i.e., commercial/industrial) water use and reduced residential demands from the integration of low-flow plumbing fixtures in new construction and the replacement of old appliances and plumbing fixtures with new water efficient versions. Figure 4.12 shows gross total per capita use rates for potable supplies (i.e., total demand for <u>all</u> public supply uses divided by total population, not just the residential demand component). Use varies annually, but the data clearly show a general downward trend in statewide per capita use rates. However, the per capita demands vary greatly among public community water systems, depending on several critical factors, including but not limited to: (a) the mix of residential, industrial, commercial and public facility land uses; (b) geographic location; and (c) system water losses.

From a difference perspective, Figure 4.13 shows per capita consumptive use in the potable supply sector, where the trend, though variable, is certainly not decreasing and possibly slightly increasing. The variability is driven, in part, by normal precipitation and temperature variations. The trend is driven, in part, by increases in outdoor water use for non-potable purposes such as landscape irrigation and

recreation. And from the likely extension of the peak demand season due to the warmer temperatures New Jersey has and will continue to have.

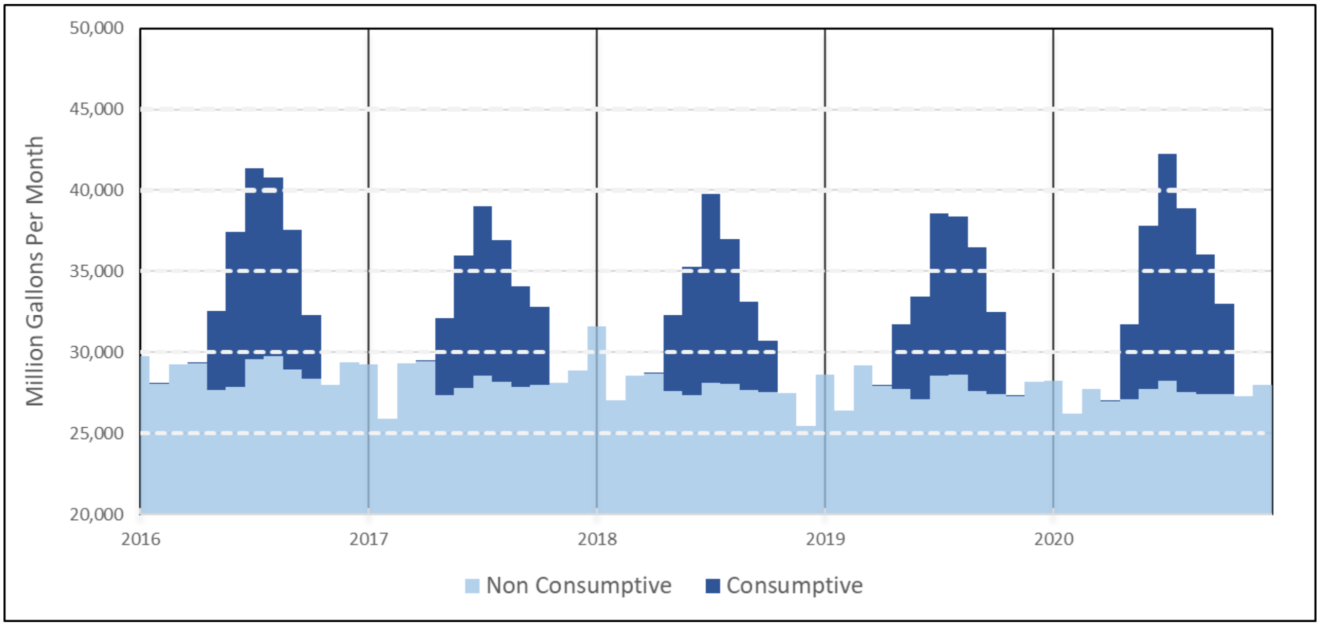

Figure 4.11 Statewide Monthly Consumptive and Non-Consumptive Potable Supply Use, 2016-2020.

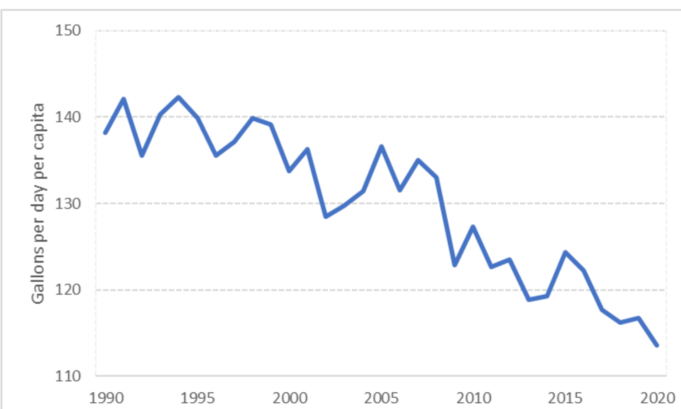

Figure 4.12 Gross Potable Supply Demands Per Capita, 1990 to 2020.

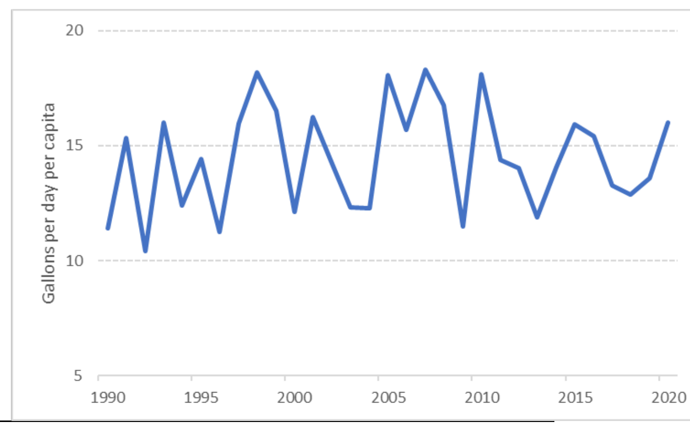

Figure 4.13 Potable Supply Consumptive Use Per Capita, 1990 to 2020.

ESTIMATING FUTURE WATER NEEDS

Forecasts of future water needs play an important role in water supply planning. DEP commissioned a report from Rutgers University to estimate 2040 demands for 584 public community water systems (PCWS); the report was published in 2018 (Van Abs, et al., 2018). The report provided a detailed statewide assessment of residential per capita water demands and how they differ geographically and

seasonally, based on monthly household demand data representing 45% of all residential customers in New Jersey. It also included the first statewide analysis of water losses based on available data from DEP and the Delaware River Basin Commission (DRBC). A spreadsheet model provided multiple demand scenarios based on different levels of residential conservation and water loss reduction.

While results differed among the PCWS, the statewide demands under the conservation scenarios were more than 10% lower than the "business as usual" scenario. The largest 37 PCWS, which supply 80% of all residential customers, emphasize the importance of analyzing individual systems, as 26 showed flat or declining demands under the best Conservation scenario, while 11 showed increasing demands. Of those with increasing demands, some are isolated systems with few options for additional supplies through interconnections, while others are in highly interconnected regions.

For the Plan, the Rutgers model was updated to estimate demands for the year 2050. The new analysis incorporates much of the 2040 model, especially the per capita residential demands, with the following updates:

- population projections using recent (though pre-2020 census) models from New Jersey's Metropolitan Planning Organizations (MPOs), the North Jersey Transportation Planning Agency, the Delaware Valley Regional Planning Commission, and the South Jersey Metropolitan Planning Organization;
- updated water loss analyses using more current information from DEP and DRBC;
- updated PCWS service area maps from DEP;
- updated analyses of the split between residential, commercial and industrial demands for PCWS;
- updated analyses of seasonal demands in coastal PCWS with large tourist water demands; and
- comparison of the demand scenarios to current available water supplies, based on water allocation permits and contracts as tracked through the DEP Water Deficit/Surplus Analysis system.

The detailed methodology and results are provided in Appendix D – 2050 Forecast Water Demands for Public Community Water Systems. The following discussion summarizes the results.

POPULATION PROJECTIONS

The MPO projections are based on pre-2020 census population estimates, which introduces some differences between the MPO estimates for 2020 and the 2020 census results. Statewide, the MPOs projected 8.94 million people for 2020, but the 2020 census population is 9.28 million, 3.7% higher. The MPO projections to 2050 show a state population of 10.05 million, an increase of 12.4% from the 2020 MPO estimate, but only 8.3% above the 2020 census population. The median difference for all municipalities is 3.6% (average of 5%), while the median for the largest 50 municipalities (based on 2020 size) is 4.4% (average of 5.2%). Table 4.2 provides examples of the population differences for the largest 10 municipalities. The differences range from 2% in Woodbridge Township to 32.6% for Lakewood Township. These differences create some uncertainty in the analysis of future water demands, but there are no other municipal population projections to the year 2050. Therefore, the MPO values are used in this Plan for planning purposes, with the expectation that during the next few years each MPO will update

its projections using the 2020 census, at which point the PCWS water demand forecasts can likewise be updated. It is important to note that the PCWS demand forecast scenarios are based on percent population changes between 2020 and 2050; the method uses 2020 and 2050 MPO values, providing a sufficiently robust percentage change, even though the 2020 MPO starting point is different from the 2020 census.

Table 4.2 Largest 10 Municipalities: Population Estimates and Projections

Municipality	County	2020 Census Population	Percent Change 2010-2020	% Difference (2020 Census/ 2020 MPO Estimate)	2020 MPO Population Estimate	2050 MPO Population Estimate
NEWARK CITY	Essex	311,549	12.4	8.4	286,551	334,773
JERSEY CITY	Hudson	292,449	18.1	9.8	265,127	387,098
PATERSON CITY	Passaic	159,732	9.3	5.2	151,568	179,976
ELIZABETH CITY	Union	137,298	9.9	5.0	130,593	158,829
LAKEWOOD TWP	Ocean	135,158	45.6	32.6	97,318	118,710
EDISON TWP	Middlesex	107,588	7.6	5.7	101,651	108,805
WOODBRIDGE TWP	Middlesex	103,639	4.1	2.0	101,572	111,356
TOMS RIVER TWP	Ocean	95,438	4.6	2.5	93,106	111,843
HAMILTON TWP	Mercer	92,297	4.3	5.8	87,093	88,912
TRENTON CITY	Mercer	90,871	7.0	8.9	83,148	85,861

PCWS WATER LOSSES

The water loss analyses were completely updated for this Plan, using new years of data from the DRBC (all of which used the Water Loss Audit v.5 of the American Water Works Association) and a major new data set from DEP. For both data sets, the years 2018 and 2019 were used to reflect pre-pandemic patterns. The detailed results are provided in Appendix E– New Jersey Assessment of Water Losses for Public Community Water Systems.

Statistical analyses provided new insights. First, analysis confirmed that the DRBC and DEP data could be used in combination, representing 234 PCWS (with DRBC data being used for any PCWS that also reported data to DEP). Second, the analysis showed that PCWS with service areas located primarily in bedrock geology had significantly different results than PCWS in the coastal plain. With the new data, there was no statistically significant difference between the small, medium and large PCWS in each region; PCWS results are therefore combined by region. The statistically significant differences between the Bedrock and Coastal Plain water losses provide a basis for different planning targets in the two regions.

In all cases, the real water losses will be slightly lower. Using the DRBC data set, which provides estimates of real, apparent and total water losses, real water losses comprise the vast majority of total water losses

(average of 85.5% and median of 94%). Table 4.3 shows the results for Water Losses (Real plus Apparent) and a Real Losses result that assumes real water losses are 90% of all water losses.

Table 4.3 Median and 25th Percentile PCWS Water Losses

Water Loss Metric	Median Bedrock % Water Loss	Median Coastal % Water Loss	25th Percentile Bedrock % Water Loss	25th Percentile Coastal % Water Loss
All Losses	17.0	12.0	13.0	8.1
Real Losses	15.3	10.8	11.7	7.3

The median results are used as an indicator of what the median utility currently achieves regarding water losses. The 25th percentile results are used as an indicator of what PCWS with robust asset management programs can achieve regarding real water losses. The consistent differences between PCWS in the two geophysical areas indicate that PCWS in the Bedrock Provinces may have a long-standing potential for higher real water losses, which will be a factor in 2050 water withdrawals in those areas.

RESIDENTIAL, INDUSTRIAL AND COMMERCIAL (RIC) DEMANDS

While many small PCWS only have a single customer category (usually residential), larger systems will have a mix of residential (single family and multi-family), industrial, commercial and public facilities customers. Public facilities are included in the commercial category as similar in nature though not ownership. Estimates of residential, industrial and commercial (RIC) demands for all PCWS are feasible using a combination of (a) service area distribution among the three major land use categories, and (b) specific RIC data from some PCWS.

The new analysis includes recent demands by customer category from 35 PCWS, allowing for a better estimation of RIC demands using extrapolations based on land use distributions. RIC data were received from NJ American Water (multiple systems), Evesham Township MUA, East Brunswick, Ridgewood, Passaic Valley Water Commission, Sayreville, South Brunswick, and Washington Township (Gloucester County) MUA. Earlier data provided by Newark were also used.

In addition, DEP received 2019-2021 residential demand information (as a percentage of total billed demands) from 210 PCWS as part of the Water Quality Accountability Act reporting process. While a few of the reported values are questionable, most results can be used as part of the analysis. Figure 4.14 shows the results for all 210 PCWS that provided results, compared to the percentage of their developed service area (i.e., excluding forests, wetlands, open waters and parks) in residential land use.

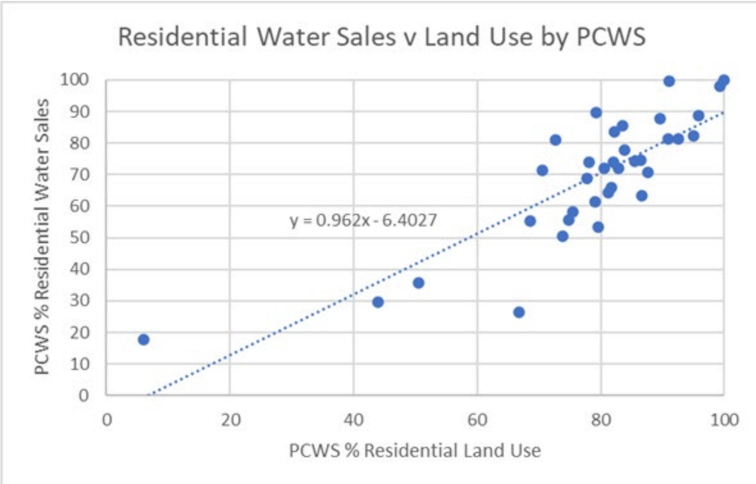

Figure 4.14 Percent PCWS Residential Demands Relative to Residential Land Use (n=210).

The combined data allowed for improved estimates for residential, industrial and commercial (including public facility) demands across all PCWS. Reported data were used where available. The reported information was used to develop relationships between land use coverage in the PCWS service area and sector demands, which were then applied to the remaining PCWS. The full analysis is provided in Appendix F– Estimating New Jersey Residential, Industrial and Commercial Demands by PCWS.

SEASONAL DEMAND ANALYSIS FOR COASTAL AND NON-COASTAL PCWS

Most PCWS have somewhat higher summer-season demands (June through September) than for the rest of the year, reflecting outdoor water demands such as landscape irrigation. However, some PCWS have a very different pattern of demands that reflect major population shifts during the summer tourist season, where resident populations can jump sharply. For this reason, these tourism centers need to be identified and treated differently in the modeling process than other PCWS. Based on a review of monthly demand data for 464 PCWS from DEP's NJ Water Tracking (NJWaTr) database, the median ratio of summer to non-summer demands for non-coastal PCWS (407 systems) is only 1.2, indicating a 20% increase in the summer. Coastal PCWS were defined as those with over 50% of their service area within one mile of the coast along the Jersey Shore (Monmouth, Ocean, Atlantic and Cape May counties), and were further subdivided into Barrier Island and Non-Barrier Island PCWS. The latter group (24 systems) show a significantly higher median ratio of summer to non-summer demands, of 1.55. However, the Barrier Island PCWS (33 systems) show a markedly higher ratio, of 3.17, indicating that the summer demands are three times the non-summer demands. Figure 4.15 shows the results for the four PCWS categories.

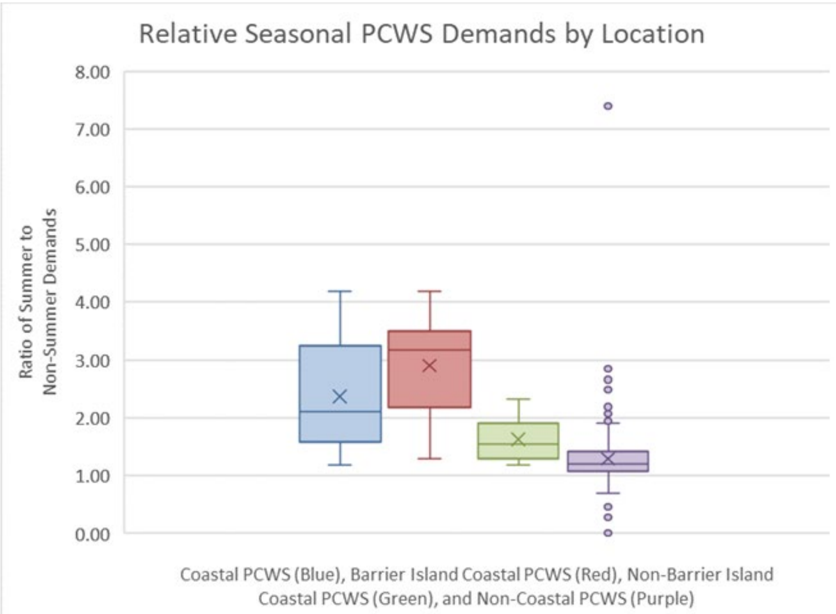

Figure 4.15 Seasonal Demand by PCWS Category.

Even within the Barrier Island systems, the results differ a great deal. Table 4.4 shows the summer and non-summer average demands for key tourism-focused PCWS. Atlantic City, which has a year-round tourism industry (casinos), has a ratio of only 1.3, close to the non-coastal median. Avalon, on the other hand, has a summer demand more than four times its non-summer demands.

Table 4.4 Summer and Non-Summer Demands for Barrier Island Coastal PCWS (>1 mgd Annual Average)

PCWS (>1 mgd Annual Average Demand)	Summer Average Demand (mgd)	Non-Summer Average Demand (mgd)	Ratio of Summer to Non-Summer Demands
Atlantic City MUA	10	7.8	1.3
Wildwood Water Dept	6.3	2.5	2.6
NJ American Water Co	4.7	1.5	3.2
Brigantine Water Dept	2.8	1.1	2.6
Lower Twp MUA	2.0	1.2	1.7
Cape May Water & Sewer Utility	2.0	0.95	2.1
Margate Water Dept	2.2	0.84	2.6
Ventnor City Water & Sewer Utility	1.7	0.98	1.7
Avalon Water & Sewer Utility	2.2	0.54	4.2

2050 PCWS DEMAND SCENARIO RESULTS

The final step in the PCWS demand projections is to use the results of the analyses discussed above to create a new demands model for the year 2050. Full results are available in Appendix D- 2050 Forecast Water Demands for Public Community Water Systems. The model has the following general structure:

1. **2020 Demands**: For each of the 583 PCWS in DEP's Deficit/Surplus Analysis spreadsheet, use the peak annual demands and the 2016-2020 annual average demands to estimate four demand

components: total water losses, residential demand, commercial demand, and industrial demand. Separate commercial and industrial demands were only available from PCWS that supplied the relevant information (35 PCWS). For the other PCWS, commercial and industrial demands were combined and calculated by subtracting residential demands and water losses from the annual value. For each PCWS, summer and non-summer total demands are calculated based on the seasonal analysis discussed above.

2. **2050 Demands, Static Per Capita Demands**: This analysis projects water demands to the year 2050 assuming no change in residential per capita demands; total residential demands change by the percentage population change, either higher or lower. Commercial demands also change by percentage population change, based on the assumption that changes in residential populations and commercial land uses are closely correlated, with the commercial land uses reflected sources of jobs and retail sales for the nearby population. Industrial demands are assumed to be unchanged, as there is no viable approach for estimating changes in industrial production. Only 50 PCWS have service areas with industrial land use greater than 10%. In some cases, those industrial land uses will have minimal water demands relative to land area (e.g., warehousing) while in other cases the water demands will be large (e.g., beverages).

   Water Loss Scenarios: This analysis also includes three scenarios for water losses.

   a. The first uses the current water loss percentage, where available, or the median water loss rate for either coastal or bedrock areas where a PCWS-specific rate is not available.
   b. The second applies the median water loss percentage to all PCWS ("Nominal Loss").
   c. The third applies the 25th percentile water loss percentage ("Optimal Loss") to all PCWS.

   There is no specific method for projecting water losses, as each PCWS will have its own assessment management approach and will differ in customer base, land use patterns, infrastructure age, etc. Using the three percentages (current, median and 25th percentile) provides a way of assessing potential impacts if a specific PCWS remains at current levels or moves toward the median or 25th percentile (either up or down from current levels). These scenarios reflect the potential for PCWS to either reduce or increase their water loss rates.

3. **2050 Demands, Declining Per Capita Demands**: This analysis also projects PCWS demands to the year 2050, but assuming that residential and commercial conservation will reduce demands by 10% from the prior analysis. This assumption differs from the more detailed approach used in the 2018 model for the year 2040, which evaluated potential residential demand changes based on land use density and recent per capital demands. However, the per capita demands are now somewhat less current and the projection has been extended from 2040 to 2050. Using a single value of 10% conservation over the period from 2020 to 2050 provides insight into potential water savings. It also allows the model to be modified to any desired percentage to test scenarios. The three water loss scenarios are used for this also.

The analysis was performed for all 583 PCWS listed in the DEP Deficit/Surplus Analysis spreadsheet (current as of June 2022). Of these, three systems are excluded from the discussion below because they do not have their own service areas, but rather provide bulk treated water to other PCWS that are

included in the analysis. Of the 580 PCWS remaining, 541 have available data for peak demands, and 552 have available data for 2016-2020 annual average demands. The statewide results for all PCWS with data are shown in Table 4.5. The largest 10 PCWS account for 50% of the total 2016-2020 average demands, the largest 64 PCWS account for 80%, and the largest 118 PCWS account for 90%.

Table 4.5 2020 Statewide Water Demands

D/S Total Limits (mgd)	D/S Peak Annual Demand (mgd)	NJWaTr 2016-2020 Average Demand (mgd)
1,986	1,338	959

The 2050 results for the largest 10 PCWS (by 2016-2020 average demands) are shown in Table 4.6. Compared to the statewide average growth between 2020 and 2050 of 12.4%, Jersey City MUA has a high rate of expected growth at nearly 33%. Several systems have expected population changes at roughly the statewide average, but others, such as Trenton Water Works (serving four municipalities) are projected to experience no growth or slight reductions in population.

The relationship between the 2016-2020 average demands (used as the 2020 base) and the various 2050 scenarios primarily reflects a combination of population and water loss changes. For example, some systems show a major drop between 2020 and 2050, despite increasing population, indicating that reaching the median (nominal) or 25th percentile (optimal) water loss rates would decrease demands significantly. In other cases, the current water losses are not greatly different from the nominal water losses used in the scenarios, and so population change will be the major factor. All of the largest ten PCWS are in bedrock geology service areas, except for New Jersey American Water-Coastal North. For the bedrock PCWS, the nominal water loss is 17%; for coastal plain PCWS, the nominal water loss is 12%.

The most optimistic scenario for annual average water demands is the last, where a 10% reduction in residential and commercial demands is assumed along with optimal water losses (13% for bedrock and 8.1% for coastal plain). In this scenario, for the largest 10 PCWS, the only PCWS with projected demands greater than the 2020 baseline is Jersey City. Given that older systems will have a harder time meeting the optimal water loss scenario, it is likely that 2050 demands will be higher. Figure 4.16 shows the percent change in average annual demand based on a comparison of this scenario to 2016-2020 average annual demand. Due to the optimistic nature of the scenario applied, some systems show significant decreases in demand. Smaller systems that project to experience population growth may be on the opposite end of the spectrum, showing significant percent increases in demand.

Table 4.7 provides similar information but with 2020 peak demands compared to the equivalent scenarios. Again, Jersey City MUA stands out as the only PCWS among the largest 10 that has projected peak demands exceeding the 2020 baseline across all scenarios. It is also the only one of the 10 where a peak demand scenario for 2050 exceeds the total limits of the PCWS as determined by DEP (56.8 mgd, from its two reservoirs). In total, 22 PCWS have at least one scenario (generally a peak demand scenario) that exceeds the PCWS total limits. In some cases, the PCWS already purchases water from other systems with sufficient capacity to meet their needs, but in others the PCWS is entirely reliant on local sources

and therefore would face greater difficulties in expanding supplies. A few PCWS have one or demand scenarios that would only come into play if their current water loss rates increased to the median for their region; these systems currently have low water loss rates.

None of the scenarios should be viewed as predictions. Rather, they provide a suite of possibilities showing the relative effects of population change, asset management effectiveness and water use efficiency. By linking these demand scenarios to specific water withdrawals, it is feasible to evaluate whether one or more scenarios would involve an excessive withdrawal from a resource, based on water allocation permits, safe yield models, or aquifer models.

Table 4.6 2050 Water Demand Projections from 2016-2020 Average Demands for Largest 10 PCWS Systems

PCWS System			Population	NJWaTr	2050 No Conservation Scenario		2050 Conservation Scenario	
PWSID #	County	Name	% CHANGE 2020-2050	2016-2020 Average Demand (mgd)	Nominal Water Loss Scenario (mgd)	Optimal Water Loss Scenario (mgd)	Nominal Water Loss Scenario (mgd)	Optimal Water Loss Scenario (mgd)
NJ0238001	Bergen	Suez Water New Jersey – Haworth	11.8	104	111	105	99	94
NJ2004002	Union	New Jersey American Water – Raritan System	11.0	98	79	75	72	69
NJ0714001	Essex	Newark Water Department	10.9	53	42	41	40	38
NJ1605002	Passaic	Passaic Valley Water Commission	13.0	48	53	51	48	46
NJ1345001	Monmouth	New Jersey American Water – Coastal North	-1.4	39	36	35	33	31
NJ0712001	Essex	New Jersey American Water – Passaic Basin	5.1	32	31	30	28	27
NJ0906001	Hudson	Jersey City MUA	32.9	31	41	39	36	35
NJ0327001	Burlington	New Jersey American Water – Western Division	-0.7	28	28	27	25	24
NJ1111001	Mercer	Trenton Water Works	-0.1	26	25	24	23	22
NJ1225001	Middlesex	Middlesex Water Company	6.4	20	23	22	21	20
TOTALS (Largest 10 PCWS, representing 50 percent of total 2016-2020 average statewide demands)				480	469	448	426	406
TOTALS (Largest 64 PCWS, representing 80 percent of total 2016-2020 average statewide demands)				763	771	736	698	666
TOTALS (All PCWS) NB: Many very small systems lack available information on current and therefore projected demands				957	977	933	883	843

Table 4.7 2050 Water Demand Projections from 2016-2020 Peak Demands for Largest 10 PCWS Systems

PCWS System			Population	Deficit/ Surplus	2050 No Conservation Scenario		2050 Conservation Scenario	
PWSID #	County	Name	% CHANGE 2020-2050	Peak Annual Demand (mgd)	Nominal Water Loss Scenario (mgd)	Optimal Water Loss Scenario (mgd)	Nominal Water Loss Scenario (mgd)	Optimal Water Loss Scenario (mgd)
NJ0238001	Bergen	Suez Water New Jersey – Haworth	11.8	103	109	104	98	93
NJ2004002	Union	New Jersey American Water – Raritan System	11.0	141	114	108	105	100
NJ0714001	Essex	Newark Water Department	10.9	76	62	59	58	55
NJ1605002	Passaic	Passaic Valley Water Commission	13.0	84	94	89	85	81
NJ1345001	Monmouth	New Jersey American Water – Coastal North	-1.4	47	44	42	39	38
NJ0712001	Essex	New Jersey American Water – Passaic Basin	5.1	36	36	34	32	31
NJ0906001	Hudson	Jersey City MUA	32.9	49	64	61	57	55
NJ0327001	Burlington	New Jersey American Water – Western Division	-0.7	43	43	41	39	37
NJ1111001	Mercer	Trenton Water Works	-0.1	29	27	26	25	23
NJ1225001	Middlesex	Middlesex Water Company	6.4	41	47	45	42	40
TOTALS (Largest 10 PCWS, representing 50 percent of total 2016-2020 average statewide demands)				650	637	608	579	553
TOTALS (Largest 64 PCWS, representing 80 percent of total 2016-2020 average statewide demands)				964	972	928	880	841
TOTALS (All PCWS) NB: Many very small systems lack available information on current and therefore projected demands				1203	1220	1165	1104	1054

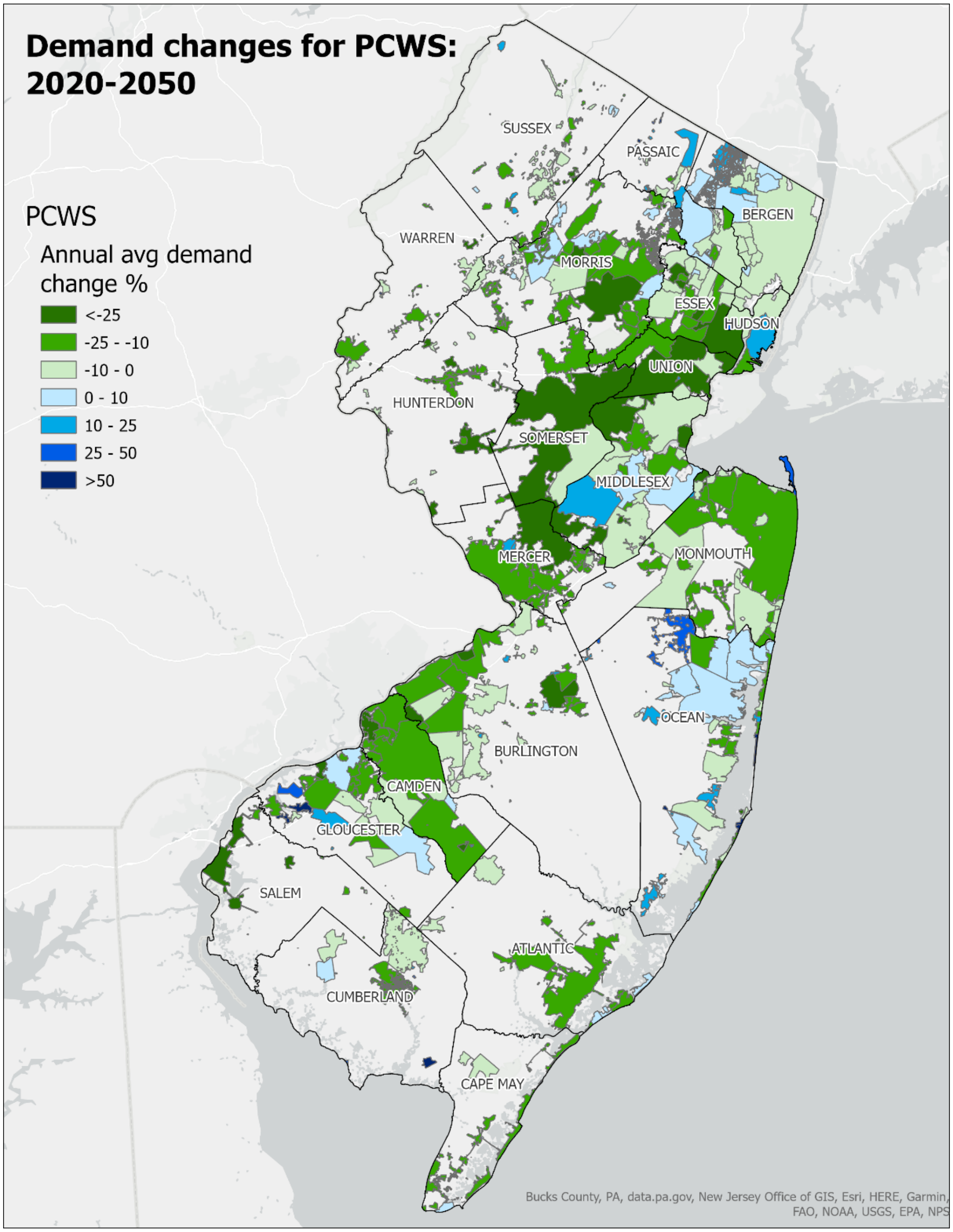

Figure 4.16 Percent change from current (2020) annual average demands to projected (2050) demands based on the optimal water loss scenario.

IMPACTS AND SHORTFALL ANALYSIS

Natural resource availability from New Jersey's three primary resources (surface water supply reservoirs, streams and unconfined aquifers, and confined aquifers), was quantified and then compared to current

and future demand to determine net resource availability. These results were also compared to the administrative availability. Each resource has a specific set of concerns and limitations and are discussed below. The results of the three individual analyses are combined in the sections below and summarized in Table 4.8. In general, New Jersey is a water rich state, but it is also densely populated; therefore, regional and sub-regional shortfalls do occur, and water-supply droughts and emergencies periodically occur. Potential climate change driven impacts on water availability create additional uncertainty, but initial assessment conducted for this Plan update shows that supplies will remain the same or slightly increase (but more work is needed to conform these findings). The information contained below is meant to be used for water resource management and needs to be used in conjunction with the established permitting/regulatory process.

UNCONFINED GROUNDWATER AND SURFACE WATER

The withdrawal of water from the surface water and unconfined aquifer system reduces streamflow. This is a function of water depletion due to depletive and consumptive water loss within the HUC11, balanced by any water gains from imports to the HUC11. The net loss is then compared to the low-flow margin, an estimate of the amount of water that can be lost from the surface water and unconfined aquifer system without creating unacceptable ecological impacts (see Chapter 2 for more details). The results are provided by HUC11 as a starting point for analysis of existing and future water demands, but they are not definitive. The availability of water supply from unconfined and surface water may be additionally constrained by the following:

- wetlands and ecologically sensitive areas affected by existing or proposed wells;
- watersheds where the withdrawal of 25% of the Low Flow Margin represents an unacceptable level of streamflow reduction during low-flow periods (e.g., the 7Q10);
- interference or new or increased withdrawals with other water users;
- contamination and other water quality issues; or
- restrictions as a result of the Highlands Act, Highlands Regional Master Plan and Highlands Preservation Area Rules (N.J.A.C. 7:38).

After documentation of the stream low flow margin (LFM) method in NJGWS Technical Memorandum 13-3 and initial implementation in the 2017 Plan, it was determined that several modifications were needed to more accurately reflect the complex hydrogeologic and hydrologic relationships that exist within a drainage basin, and to better identify regions that may be experiencing hydrologic stresses and require further investigation or action by the DEP. Those changes are outlined below. Unless specifically noted, the method components are the same as defined in TM13-3.

- Water use data period:
    - The 2017 Plan used data from 2000-2015.
    - The 2011-2020 period is used in this Plan to determine peak use due to stabilization of trends in water use over that period.
- Peak use representation:

- Peak annual use will be selected from the three-consecutive year period with the highest average net water loss from 2011-2020 with the last year used to indicate the multi-year period. The 2017 Plan used the single recent year with highest loss.
- The change is designed to reflect the complexity of unconfined groundwater storage and corresponding base flows, and that a single year may not accurately represent current peak use conditions. DEP recognizes that some aquifer areas may respond more quickly to withdrawals during dry periods; this issue is addressed through the water allocation permit process.

- Discharges to saline waters:
  - These discharges will no longer be incorporated into remaining available water calculations since such discharges have very different hydrologic impacts on the watershed. These volumes are still tracked in the summary data tables as potential future resources.
- Additional considerations:
  - Upstream stressed HUC: Highlights any HUC that is downstream of another that has been identified as stressed.
  - In a stressed WMA: Net loss was subtracted from total availability for each WMA in the same manner that is carried out on a HUC-by-HUC basis. If a WMA is identified as stressed, all HUCs within are flagged for a potential availability limitation.

The following charts depict water loss by HUC11 from the unconfined groundwater and surface water (aka non-reservoir) sources only and how different uses impact overall water loss. For each chart, the coastal areas are shown in gray (Ocean/Bay HUCs) and as having limited availability because any treated wastewater effluent cannot be reused once discharged, as discussed above. In addition, for Figures 4.17, 4.19 and 4.21(a) and (b), the Highlands Region is whited out as the Highlands Council's planning water resource planning policies in the Highlands Regional Master Plan have primacy, pursuant to 2004 amendments to the Water Supply Management Act.

- Figure 4.17 shows the estimated amount of unconfined groundwater and surface water lost from each HUC11. Of 151 HUC11s, eight indicate more than 10 mgd of net loss, but many HUC11 show losses from 0-3 or 3-10 mgd. The areas showing highest gains (3-10 or more than 10 mgd) have major freshwater discharges of treated wastewater effluent, generally from regional systems that draw their water from other HUC11(s). The largest such flow is the Camden County Municipal Utility Authority discharge (dark blue), which is allocated to a HUC11 but technically located at the base of the HUC11 and very near a freshwater tidal reach of the Delaware River estuary.
- Figure 4.18 shows the unconfined groundwater and surface water use responsible for the greatest water loss in each HUC11. In this case "Primary Loss" means the largest source of consumptive/depletive water loss, which may or may not be a majority of the consumptive/depletive loss in the HUC11. Potable supply demands are the most frequent source of primary loss, but agricultural demands are more common in the southern area.
- Figure 4.19 shows what the amount of unconfined groundwater and surface water loss would be if withdrawals were diverting at the full rate within water allocation permits and agricultural use

certifications. The results in this chart are similar to those of Figure 4.17, but more severe in several cases and should be considered a worst case but very unlikely scenario.

- Figure 4.20 shows the water use type responsible for the greatest amount of unconfined groundwater and surface water lost at full allocation. In this case, there is a major shift from Figure 4.18, showing far more HUC11 where potable supply demands would be the primary loss.
- Figure 4.21a was determined by subtracting peak water loss between 2011-2020 (Figure 4.17) from available water (Figure 2.4), which results in the remaining volume of water than can be depletively and/or consumptively lost from each HUC11. Areas shown as "limited availability" have net losses that exceed the LFM amounts available, and therefore are a potential concern and targets for additional analysis and planning (see Chapter 8: Regional Planning for Deficit Mitigation and Avoidance).
- Figure 4.21b shows the amount of water remaining for use from the unconfined groundwater and surface water sources only in each HUC11 assuming full allocation withdrawal. This chart should be considered a "worst case" analysis, as in many if not most cases, the full allocation level of existing permits is unlikely to be achieved. As many regions are dominated by potable supply demands, the earlier analysis of 2050 PCWS demands is relevant, showing the most PCWS are likely to have reduced, not increased, demands. Still, this chart is another factor in selecting regions for further analysis and planning.

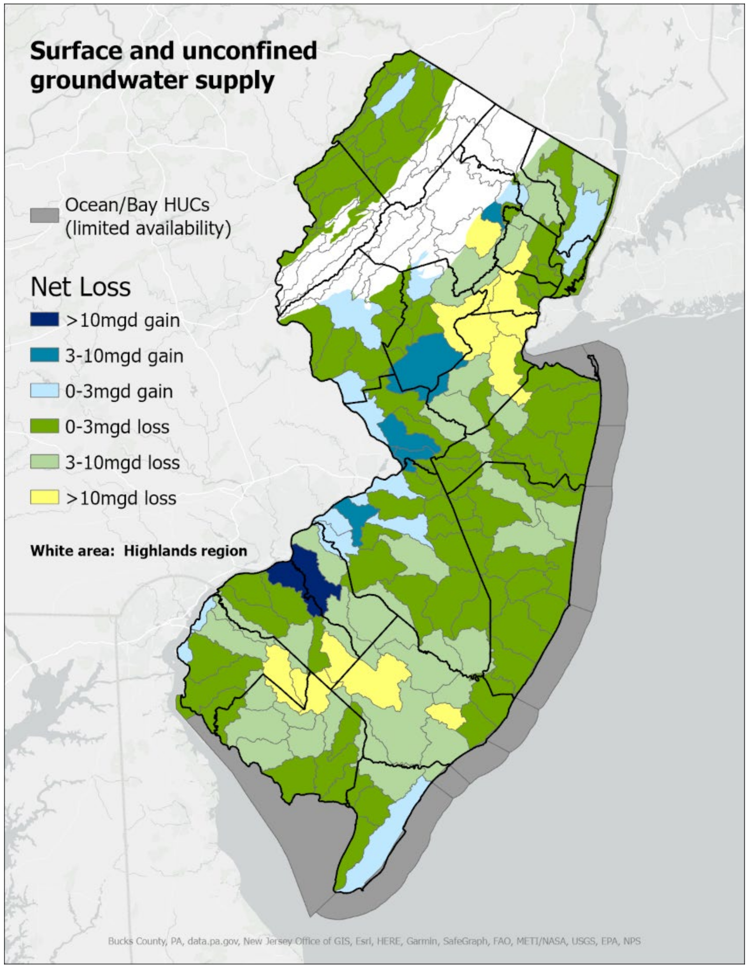

Figure 4.17 Depletive and consumptive loss from unconfined groundwater and surface water sources at peak use rates used in analysis.

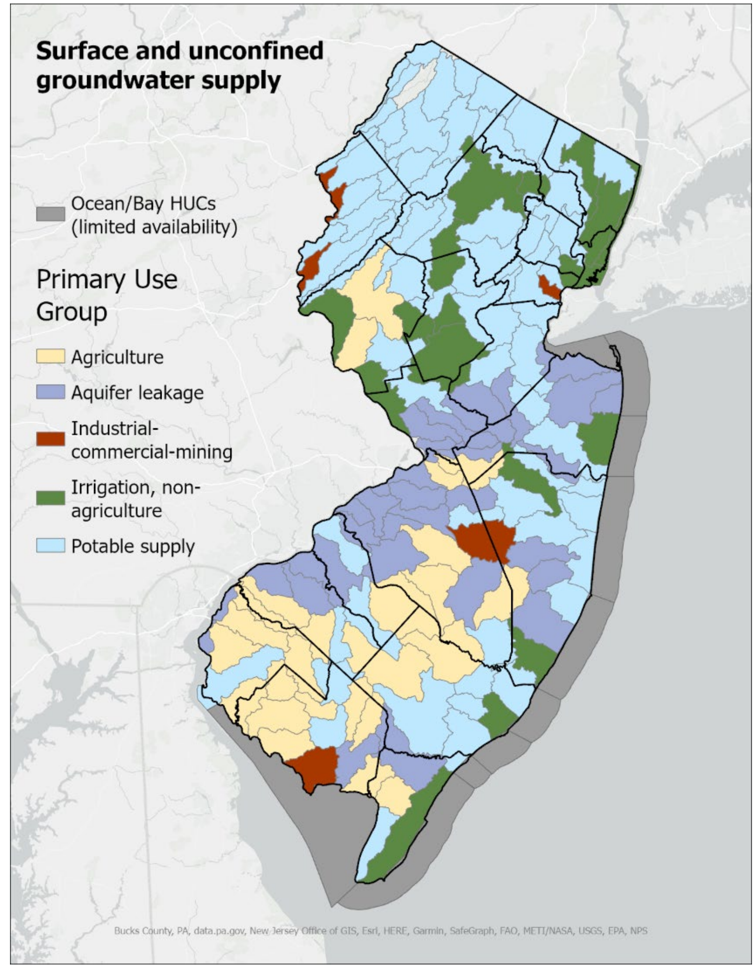

Figure 4.18 Primary causes of depletive and consumptive loss at peak use rates used in analysis.

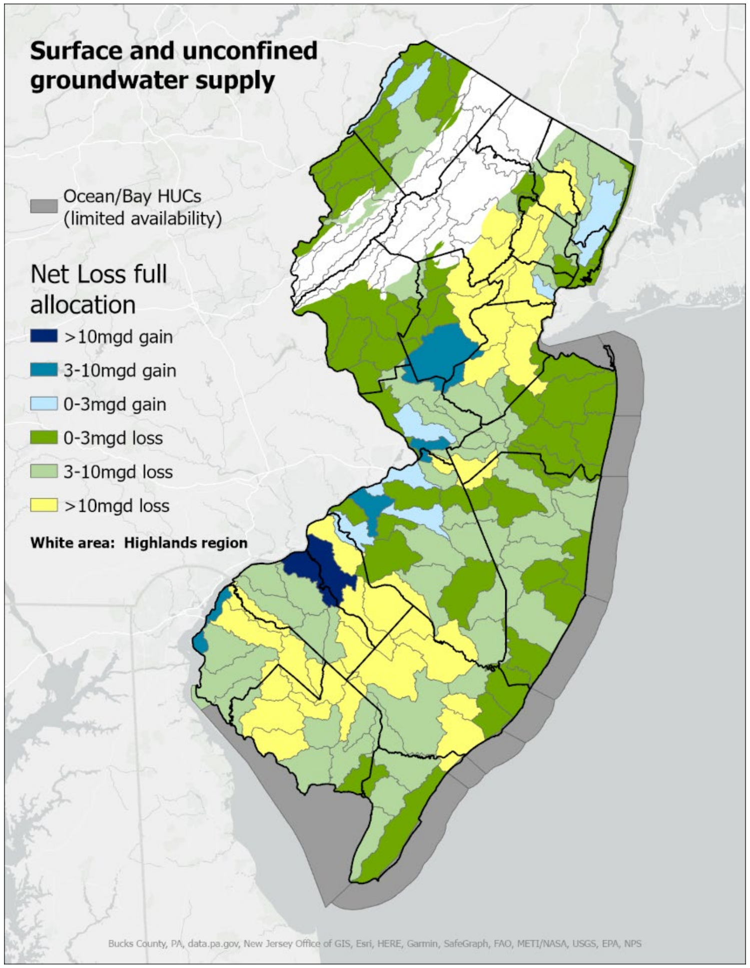

Figure 4.19 Depletive and consumptive loss from unconfined groundwaterand surface water sources at full allocation use rates as of 2020.

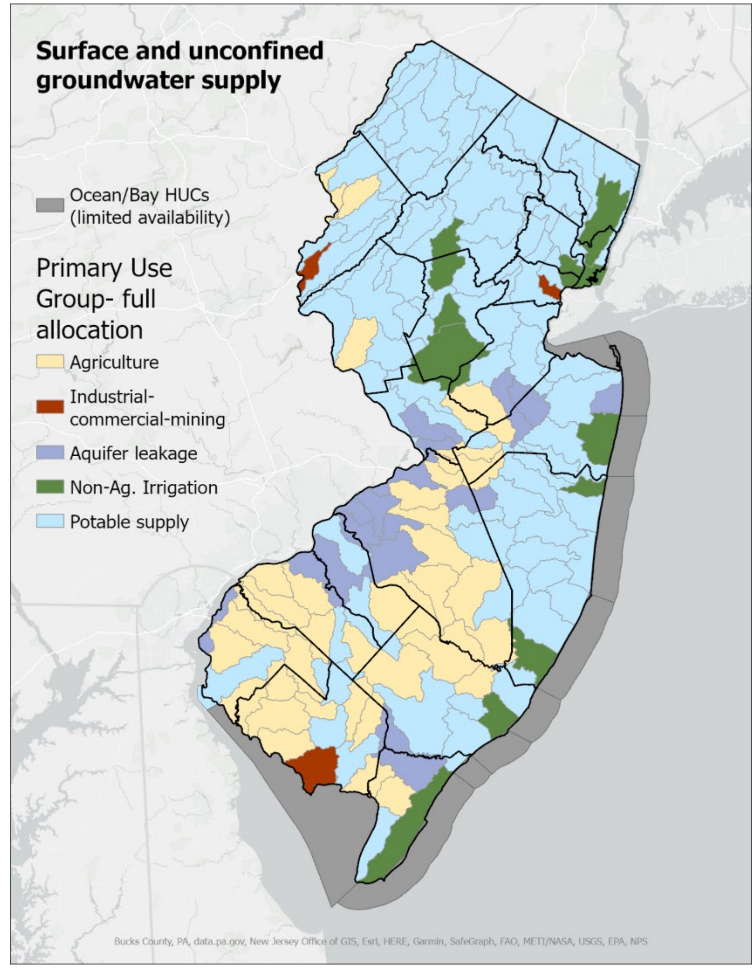

Figure 4.20 Primary causes of depletive and consumptive loss at full allocation use rates as of 2020.

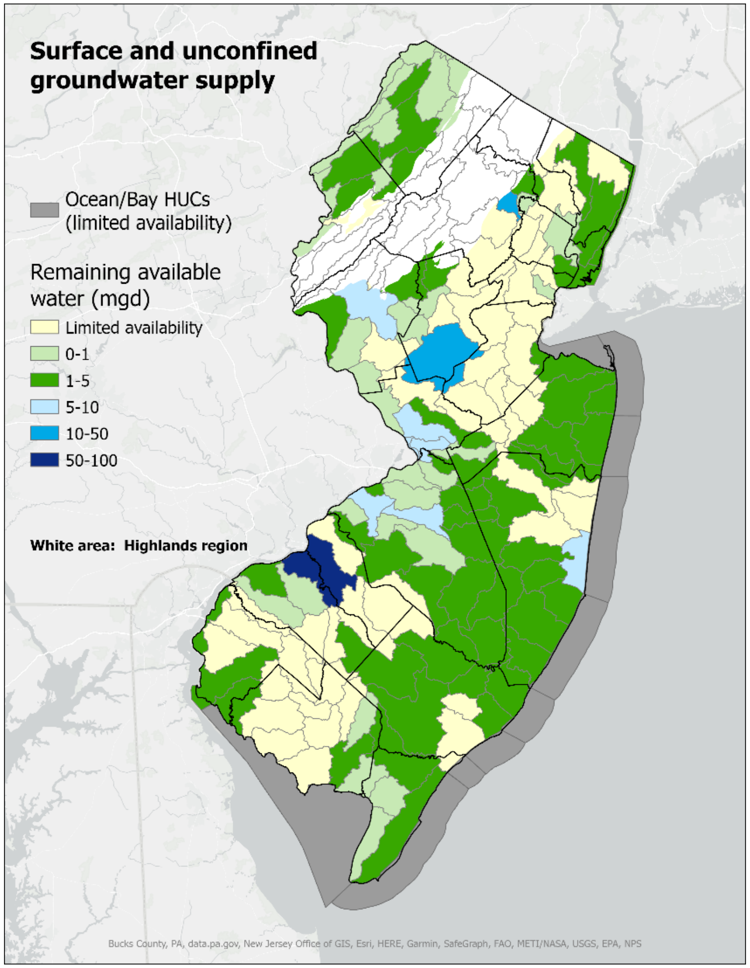

Figure 4.21a Remaining available unconfined groundwater and surfacewater for depletive and consumptive use by HUC11 at peak current use rates.

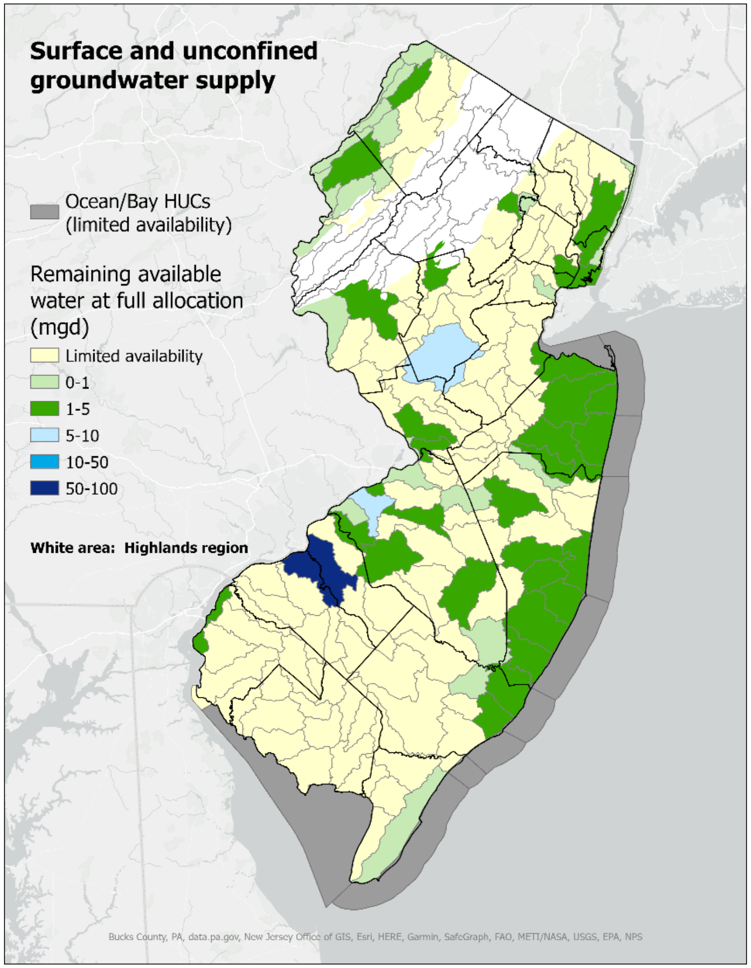

Figure 4.21b Remaining available unconfined groundwater and surface water for depletive and consumptive use by HUC11 at full allocation use rates.

CONFINED AQUIFERS

The future availability of water supply from the confined aquifers is constrained by a number of factors, including:

- Water Supply Critical Areas: Due to significant historic depletion, allocations in both Critical Areas (Figure 4.22) were significantly reduced starting in the 1980s by revisions to the Water Supply Management Act. This resulted in a rebound in groundwater levels over the following decades. Additional withdrawals from certain designated Critical Area aquifers are not allowed, except in accordance with the Act.
- Saltwater intrusion: The threat of saltwater intrusion in estuarine, seaward and bayward margins of aquifers where salty water is present or in proximity limits additional withdrawals. Pumping is usually restricted in these areas in order to not exacerbate the problem.
- Depleted water levels: Additional withdrawals are discouraged where groundwater levels are declining and not stabilizing.
- Surface Water: Near outcrop areas, confined aquifer drawdowns may migrate up-dip and affect groundwaterlevels under wetlands and surface waters. This potential impact may limit additional withdrawals in someareas.
- Interference: Increased withdrawal levels may create significant drawdowns in existing wells. In some areas this prevents DEP from approving significant additional groundwater withdrawals.

For these reasons, the assumption of this Plan is that no appreciable additional withdrawals will be feasible from the confined aquifers, though localized supplies may be available and the reconfiguration of wellfields to reduce the risk of saltwater intrusion may also result in additional supplies. Final determinations will be made during the water allocation permit review process when specific aquifer, location and volumes details can be accurately assessed.

SURFACE WATER SUPPLY RESERVOIR SYSTEMS

DEP limits the amount of water that the owner of a surface water supply reservoir system can contract to deliver to the safe yield. Safe yield that has not been committed (contracted) to a user represents the volume of water available to supply future demand increases. Table 4.8 provides the permitted reservoir safe yields. As discussed in Chapter 3, ongoing and future safe yield modeling will need to take into consideration the potential changes due to climate change, hydrologic modifications, demand pattern, etc., potentially resulting in long-term modifications of the safe yields. While the DEP reviews all contracts for the sale and purchase of water, it is the individual PCWSs who initiate these contracts.

Table 4.8 Safe Yield and current demand of the Major Surface Water Supply Reservoirs

Reservoir System	System Owner	Permitted Safe Yield (mgd)	Current Average Annual Demand (mgd)
Wanaque System	NJDWSC	148*	106
NJ Hackensack System	Veolia NA	126.5*	94
Pequannock System	City of Newark	49.1	25
Rockaway System	City of Jersey City	56.8	40
Canoe Brook System	NJAW	10.8	7
Passaic Valley System	PVWC	75	48
Raritan System	NJWSA	241	176
Swimming River System	NJAW	25	23.3
Glendola System	NJAW	5.7	3.7
Manasquan System	NJWSA	30	23.7
Metedeconk System	Brick Twp MUA	17	8.1
TOTAL		784.9	

*Reflects shared ownership of the Wanaque South Project

ADMINISTRATIVELY APPROVED WITHDRAWALS

The Water Supply Management Act recognizes that the water resources of the State are essential to the health, safety, economic welfare, recreational and aesthetic enjoyment, and general welfare, of the people of New Jersey. To protect these resources, the Legislature granted DEP authority to plan and manage water supplies as a common resource to meet State, regional and local water needs. The Act directs DEP to administer a regulatory program that manages the State ground and surface water supplies to safeguard quantity and quality, thereby protecting public health and safety as well as the natural resource itself. To that end, DEP adopted the Water Supply Allocation Permits Rules (N.J.A.C. 7:19), and the Agricultural, Aquacultural and Horticultural Water Usage Certification Rules (N.J.A.C. 7:20A), which together establish a uniform water allocation permit program that sets standards for diversions, and includes provisions related to planning, project review, monitoring, reporting, and enforcement.

The water allocation permitting program is administered by DEP's Division of Water Supply & Geoscience (DWSG). As of mid-2021, DWSG managed 578 active water allocation permits, 728 water use registrations, 717 agriculture water usage certifications, and 141 agricultural water usage registrations. Note that these permit counts will fluctuate as the DEP is actively reviewing, revising and canceling unused permits frequently. The rules require that applicants for a diversion provide sufficient information and analysis to show that the diversion will not:

- exceed the natural replenishment or safe yield;
- adversely impact other users or natural resources;

- increase the rate of saltwater intrusion;
- lead to the spread of groundwater contamination; or
- increase drawdown in a Water Supply Critical Area (see Figure 4.22) unacceptably.

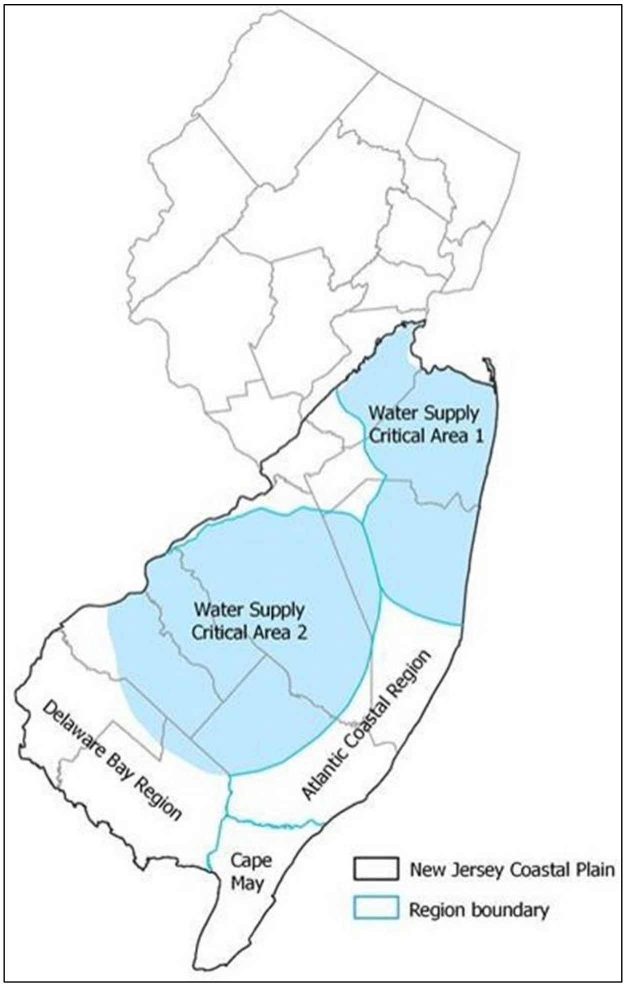

Figure 4.22 Water Supply Critical Areas of New Jersey.

New allocation permits and increases of existing allocation permits are approved or denied on a case-by-case basis. Each application goes through an extensive process including a pre-application meeting(s), an extensive technical report, preparation of a water conservation and drought management plan, site inspections, aquifer testing (if applicable), staff review, public notification and comment, and a public hearing (if requested). New or increased diversions regulated through registrations and/or certifications follow a comparable process that is defined by their specific regulation guidelines. In addition, permits and certifications being reviewed during the renewal application process are examined for compliance to permit requirements and water usage. If a facility has consistently used substantially less water than they are allocated and cannot justify the need for part or all of that remaining supply, then DWSG may reduce the allocation upon renewal. On the other hand, if a facility does not appear to have enough water for future growth, the DWSG will notify the facility that they need to obtain additional supply via permit

modification (e.g., new source, additional allocation from an existing source, bulk purchase contract from another water allocation permittee), reduce demands, or both.

To ensure sustainability of all diversions and prevent the impacts described above, the DWSG sets controls on allocations, which include:

- limits on the volume of water that may be withdrawn on a monthly and annual basis;
- precise identification of sources from which water may be diverted;
- defined uses of the diversion and effective term limit;
- specific monitoring and reporting requirements;
- passing flow requirements, if appropriate;
- contingency plans and/or mitigation requirements for adverse impacts, if appropriate; and
- review of any contracts a water supplier has entered in for sale or purchase of water on a non-emergency basis to ensure all water demands can be met.

The monthly and annual diversion limits in a water allocation permit represent administratively approved water availability. Each permit application is evaluated to determine if the sustainability requirements set forth in the rules are met. Some of the permit-wide limits are further managed with source or water resource-specific limits (e.g., well field, intake, type of use or aquifer-specific limits). The sub-permit limits do not necessarily equate to permit-wide limits but rather are designed to allow permittees the flexibility to best manage their individual demands or resource constraints. As of mid-2021 there were 5,773 mgd of surface water allocations, 1,170 mgd of unconfined groundwater allocations, and 619 mgd of confined groundwater allocations, for a total of 7,563 mgd, a drop of roughly 10% from the values reported in the 2017 Plan, in part due to changes in the analytical approach[3]. These source-specific limits reflect availability constraints which, in some cases, are different than the permit-wide allocation limits granted in water allocation permits. They provide a more accurate estimate of the resource-specific withdrawal limits of each allocation. Thus, these source-specific results are used in this analysis.

WATER ADMINISTRATIVELY AVAILABLE FOR PUBLIC WATER SYSTEMS

Water used for potable supply must also meet the requirements of the Safe Drinking Water Act (N.J.S.A. 58:12A-1 et seq.) and implementing rules (N.J.A.C. 7:10). These rules require that each purveyor meet a minimum firm capacity, which is defined as pumping and/or treatment capacity (excluding coagulation, flocculation, and sedimentation) available to meet peak daily demand when the largest pumping station or treatment unit is out of service. In other words, firm capacity is the volume of water a purveyor can reliably deliver when its largest source or facility is offline.

[3] Note that water withdrawal permits are often issued with one or more permit allocation sub-limit(s) on a subset of sites (e.g., multiple well fields under a single permit), or where a monthly limit is not equal to one-twelfth of the annual limit. This makes specific quantification of resource-specific allocation totals difficult. The Department improved its method to calculate these limits after the 2017 Plan was released so some of the differences between the two plans may be explained by the different methodologies used. Ultimately, permittees must adhere to the limits contained in each permit.

The currently allocated water volume needs to be considered along with projected future demands. Figure 4.23 shows the deficit between the allocated amount of potable water and the estimated potable water needs by community water systems based solely on demands resulting from the 2050 PCWS demands analysis. Results show areas of the State with surplus or deficit supplies in relation to currently (2022) approved potable supply, not natural resource capacity. This assessment, when combined with the natural resource limitations, provides an overview of the status (i.e., surplus or deficit) of areas of approved potable water supplies.

The analysis identifies those water systems that appear to have adequate approved allocations and system capacity to satisfy future projected population growth. Water systems surplus or deficit (as of January 2023) is compared to 2050 demand that incorporated expected changes in population as well as possible changes to the rate of water conservation and water loss (VanAbs et al., 2017). Four scenarios were selected from this report and the 2050 demand data was gathered for each scenario for each purveyor. The four scenarios that were selected for this analysis are as follow:

1. CNWL = Conservation-Nominal Water Loss Scenario assumes water conservation rate trends continue and that water loss rates are equal to the current state median rates.
2. NCNWL = No Conservation-Nominal Water Loss Scenario assumes that the current rates of conservation are static and that water loss rates are equal to the current state median rates.
3. NCOWL = No Conservation-Optimal Water Loss Scenario assumes that the current rates of conservation are static and that that all systems achieve water loss rates equivalent to the current 25th percentile for systems in New Jersey that had reported via water audits at the time of the report.
4. COWL = Conservation-Optimal Water Loss Scenario assumes that water conservation rate trends continue and that all systems achieve water loss rates equivalent to the current 25th percentile for systems in New Jersey that had reported via water audits at the time of the report.

Figure 4.23 displays a scenario in which water conservation practices continue to reduce overall system demands and where water systems are assumed to move towards optimization of water loss by mitigating leakage. Table 4.9 shows the number of systems in 2050 that will be in deficit if new sources are not brought online or if historic demands are not reduced.

Table 4.9 2050 Available Water Summary

Water Availability	**Scenario**			
(mgd)	**CNWL2050**	**COWL2050**	**NCNWL2050**	**NCOWL2050**
< 0	68	58	95	83
0 to 5	397	406	372	383
5 to 10	10	11	8	10
10 to 50	9	9	9	9
50 to 100	1	1	1	1
No Data Available	118	118	118	118

As the public water system deficit/surplus analysis is updated with revised demand and/or allocation volumes these results will change. While the usefulness of this assessment for a case-by-case analysis is somewhat limited, it is extremely useful for statewide planning with respect to targeted economic growth, optimization of existing infrastructure, identification of infrastructure needs, and development of additional sources of supply. However, to be protective of resources and provide for sustainable and reliable supply into the future, this analysis should also be considered in conjunction with the natural capacities of the resource. Refer to Appendix K for more detail on this analysis.

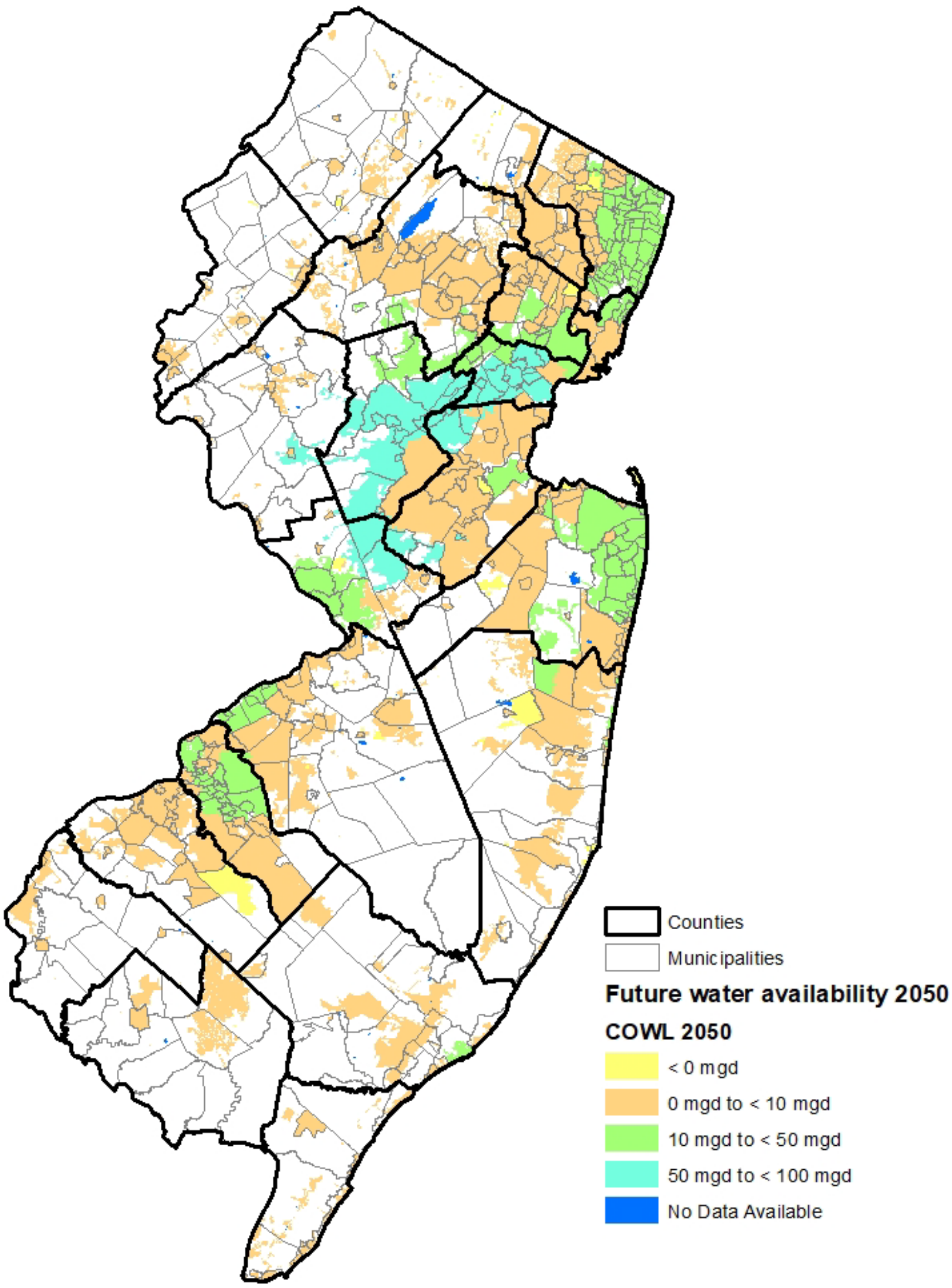

Figure 4.23 Water Administrative Availability for Public Water Systems: Results show areas of the State with surplus or deficit supplies in relation to currently approved water allocation permits for potable supply, not natural resource capacity. Results are plotted based on best available service area mapping; white spaces represent areas not part of this analysis which are generally self-supplied private domestic users. This assessment, when combined with the natural resource limitations, provides an overview of the status (i.e., surplus or deficit) of areas of approved potable water supplies. Based on the 2050 PCWS Demand Analysis and December 2022 system data available at: DEP Public Water Systems.

STATEWIDE WATER AVAILABILITY SUMMARY

The results discussed in this chapter are summarized by Watershed Management Areas (WMAs) in Table 4.10 and below. These summaries of water use and availability reflect the “big picture” of water availability throughout the State. Note that there are many complexities that are not accounted for in these WMA summaries. For example, confined aquifer boundaries do not follow surface watershed (HUC11) boundaries. At the larger WMA scale these confined vs. unconfined aquifer differences are less significant, however they may be important when a site-specific analysis is conducted. Similar boundary issues also come in to play with demand and supply since water can be piped across long distances from where it is available to where it is needed. The summaries reflect supply and demand in each WMA and does not account from the transfer of water across watershed management area boundaries. This is especially significant in WMAs 3, 4, 5, 6, 7, and 9.

Future water availability is assumed to remain the same for this analysis. The overall findings of the climate change water availability evaluations summarized in Chapter 3 indicated that no major short-term changes to water supply are anticipated. This may change as the data and models are improved.

Table 4.10 summarizes water availability for all 20 WMAs. The availability analysis includes the following factors: surface water from reservoirs (safe yield), unconfined aquifer and non-reservoir surface water based on sustainable ecological planning thresholds, and confined aquifer availability based on regulatory limits. Each availability analysis recognized and accounted for the hydraulic linkages between the resource categories, but the total identified availability estimates were based on each individual resource (e.g., reservoir system, unconfined or confined groundwater wells). The actual volume of water available to any specific subregion is a function of the total of all the water resources present in that area combined with any site-specific resource limitations.[4] This table also shows net demand from each of these resources and remaining availability. Statewide, total resources are estimated to be 1,791 mgd, and net demand to be 1,349 mgd. Surface water reservoir systems, unconfined aquifers and associated streams, and confined aquifers each provide 785 mgd, 387 mgd, and 619 mgd of availability respectively. Table 4.10 also shows an estimated change in potable demand ranging from a decrease of 20 mgd to an increase of as much as 113 mgd by 2050.

The table also shows how much water is estimated to be available from three different, currently unused sources: treated wastewater currently discharged to saline waters (619 mgd), enhanced potable

[4] Availability in a given area is a complex function of several factors. For example, administrative availability is associated with a permit and its designated use, while safe yield is related to a water system and its network of interconnections. Unconfined groundwater and surface water are derived at the watershed (HUC11) scale. Confined aquifer availability is a function of aquifer extent, groundwater divides, and critical area boundaries. Due to the nature of this information (i.e., differing or overlapping boundaries and differences in scale), summarizing water availability for any one geographic area in New Jersey is complicated.

conservation methods[5] (42 mgd), or unbuilt water supply projects[6] that currently reserved for future consideration (283 mgd).

Table 4.10 shows that total current demands exceed sustainable thresholds WMAs 7, 15 and 17. Results also show that sustainable thresholds are exceeded for the unconfined groundwater and non-safe yield surface water diversions in WMAs 6, 7, 9, 15 and 17, but that the safe yield and confined aquifer resources, where present, have available supplies. Accounting for 2050 demands doesn't increase the WMA that exceed sustainable thresholds. The majority of these deficits can be attributed to outdoor water uses and depletive losses (i.e., wastewater transfers to large regional treatment plants that discharge to the ocean and/or bay). This highlights the importance of using water more efficiently and minimizing exports.

Spruce Run Reservoir located in Clinton, New Jersey. Spruce Run is the third largest reservoir in New Jersey (after Round Valley and Wanaque).

The summaries of water use and availability in Table 4.10 are helpful in that they combine the multiple, detailed, resource-specific availabilities in a comprehensive manner. However, their usefulness in identifying appropriate water supply management options at a site-specific or even watershed level is somewhat limited. For example, to develop the WMA summaries, unconfined groundwater and surface water availabilities for each HUC11 watershed were combined into one total. The water available to any one new diversion is highly dependent on the location of the new diversion, the location of the HUC11 with the availability, and available infrastructure and resources to move water to the desired location. In addition, the underlying cause of a

[5] The potable conservation method assumes that one-third of 2016-2020 average annual potable supply consumptive use can be saved via water conservation and that water then becomes available for new or deficit offsetting potable uses.

[6] WMA 6 projects include one or more finished water interconnections to transfer water from the NJ American's Raritan Basin system to the Passaic Basin system, WMA 7 projects include transfers of water from WMA 9 via the Virginia Street interconnection or similar, WMA 9 projects includes multiple projects like the confluence pump station, Kingston Quarry and Six Mile Run Reservoir, WMA 12 projects include transfers from WMA 9 via the South River Basin Pipeline or similar type of transfer, and WMA 18 projects include expansion of the Delran surface water treatment plant or similar intake.

deficit in a WMA may result from a specific type or volume of use that can be modified, or from an allocation that will never be fully used. Also, site-specific details may limit the availability of a proposed diversion in a WMA with a surplus (e.g., adverse interference with other users and limited water availability at the site because of in-situ aquifer conditions).

To ensure sustainable water supplies, DEP will continue to review detailed data and demonstrations of alternative region-specific sustainability thresholds. DEP considered the results of the Highlands Regional Master Plan (RMP) process to define available water supply in the Highlands Region. Future water allocation and safe drinking water permit decisions, for new or modified permits as well as renewals, will be made consistent with the adopted Highlands rules (N.J.A.C. 7:38) and the Highlands RMP. DEP also will continue to work with the Pinelands Commission to ensure water allocation decisions meet Pinelands Comprehensive Management Plan (CMP) objectives.

Table 4.10 Natural Resource Availability, Demands, Remaining Availability, 2050 Estimates, and Options

WMA#	WMA Name	Natural Resource Availability (mgd)			Current Demand (mgd)			Remaining Availability (mgd)				Net Demand 2020-2050		Options for Additional Water Supply (mgd)		
		Reservoirs	Unconf GW and SW	Conf GW (sub to revision)	Reservoirs	Unconf GW and SW	Conf GW	Reservoirs	Unconf GW and SW	Conf GW	Net	Low End (mgd)	High End (mgd)	Ocean/ bay sewer discharges	Potable conservation savings	Unbuilt water supply projects
1	Up Del		30			7			24		24	-0.3	1.5		0.5	40
2	Wallkill		6			3			4		4	-0.2	0.2		0.2	
3	P-P-W-R	197	8		131	8		66	0		66	-3	-1		1.1	
4	Low Pas-Sad	75	9		48	7		27	2		29	-9	12		4.5	
5	Hack-Hud-Pas	127	6		94	2		33	4		36	-15	7	82	5.6	
6	U/M P-W-R	68	15		47	16		21	-1		19	1	9		2.6	30
7	Arthur Kill		6			17			-11		-11	9	24	303	2.8	20
8	N/S Raritan		21	0		8	0		13	0	13	1	3		3.3	
9	L Rar-Sou-Law	241	13	51	176	36	45	65	**-23**	6	48	2	15		3.2	135
10	Millstone		8	15		0	9		8	6	14	2	6		0.3	
11	Cen Del		8	4		-1	3		9	2	11	1	5		1	
12	Monmouth	61	21	69	51	5	64	10	16	5	31	1	8	139	5	23.2
13	Barnegat Bay	17	54	140	8	31	126	9	23	14	46	-8	1	47	3.7	
14	Mullica		39	10		22	6		17	4	21	0	0		0.4	
15	Gr Egg Harbor		36	49		45	46		-9	3	-6	-2	3	28	1.5	
16	Cape May		7	28		2	28		4	1	5	-2	0	16	0.4	
17	Mau-Sal-Coh		47	31		82	20		-35	12	-23	-1	2	4	1.2	
18	Low Del		24	147		-40	165		64	-18	46	1	11		3	35
19	Rancocas		19	40		-3	30		22	10	32	0	3		1.1	
20	Ass-Cro-Doc		10	34		-12	20		22	14	37	1	4		0.4	
TOTAL		**785**	**387**	**619**	**555**	**234**	**560**	**230**	**152**	**59**		**-20**	**113**	**619**	**42**	**283**

Notes for Table 4.10:

- The information summarizing Statewide Water Availability is extensive, and the Tables have been divided to properly fit the format of this document.Refer to Appendix A for additional details.
- All volumes are in millions of gallons per day (mgd).
- Columns that are blank are due the fact that the identified resource for each region are not available there. Columns with a “0 “indicate regions where that resource is present but not currently a viable supply.
- The total resource availability is based on the best available analysis using the combined sum of the amount of water available from unconfined sources of supply and surface waters based on the stream low flow margin method, the approved safe yields of existing reservoir systems, and the total permitted allocations in the confined aquifers.
- Remaining Availability is WMA-specific, and it is not appropriate to include a total sum for the entire state.
- Net demand is based upon the peak use of the resource for each HUC11 between 2011 and 2020. Not all HUC11s may have the same peak year.
- The remaining availabilities are not summed statewide because a large loss in one WMA does not offset a surplus in another WMA. Similarly, a large loss in one resource does not mean that a new source may be added (assuming all permitting requirements are met) which utilizes another source in the same WMA which has availability.
- The 2050 water demand estimates include the water purveyor needs assessment discussed earlier in this chapter and that self-supplied commercial, industrial, mining, power and agricultural water uses will remain the same.
- Increases in the resource availability may occur for reservoirs if new infrastructure is built and permitted and in confined aquifers depending upon thespecific location and construction of a new source.
- Ocean and bay discharges are not included as part of the stream low-flow margin availability, since the waters are ‘lost’ to the freshwater system; instead, these discharges are separated to indicate their reuse.

Figures 4.24-4.29 summarize key values from Table 4.10 and add spatial context to the information. In Figure 4.24, natural availability, demand, and remaining availability (balance) are summed by water region. Water regions are combinations of WMAs grouped by shared hydrography. The amount contributed to availability and demand by each of the three resource types, reservoir, unconfined groundwater and surface water, confined groundwater, varies by region, as do totals. For each of the five regions, natural availability is greater than demand, resulting in positive balances and no deficits.

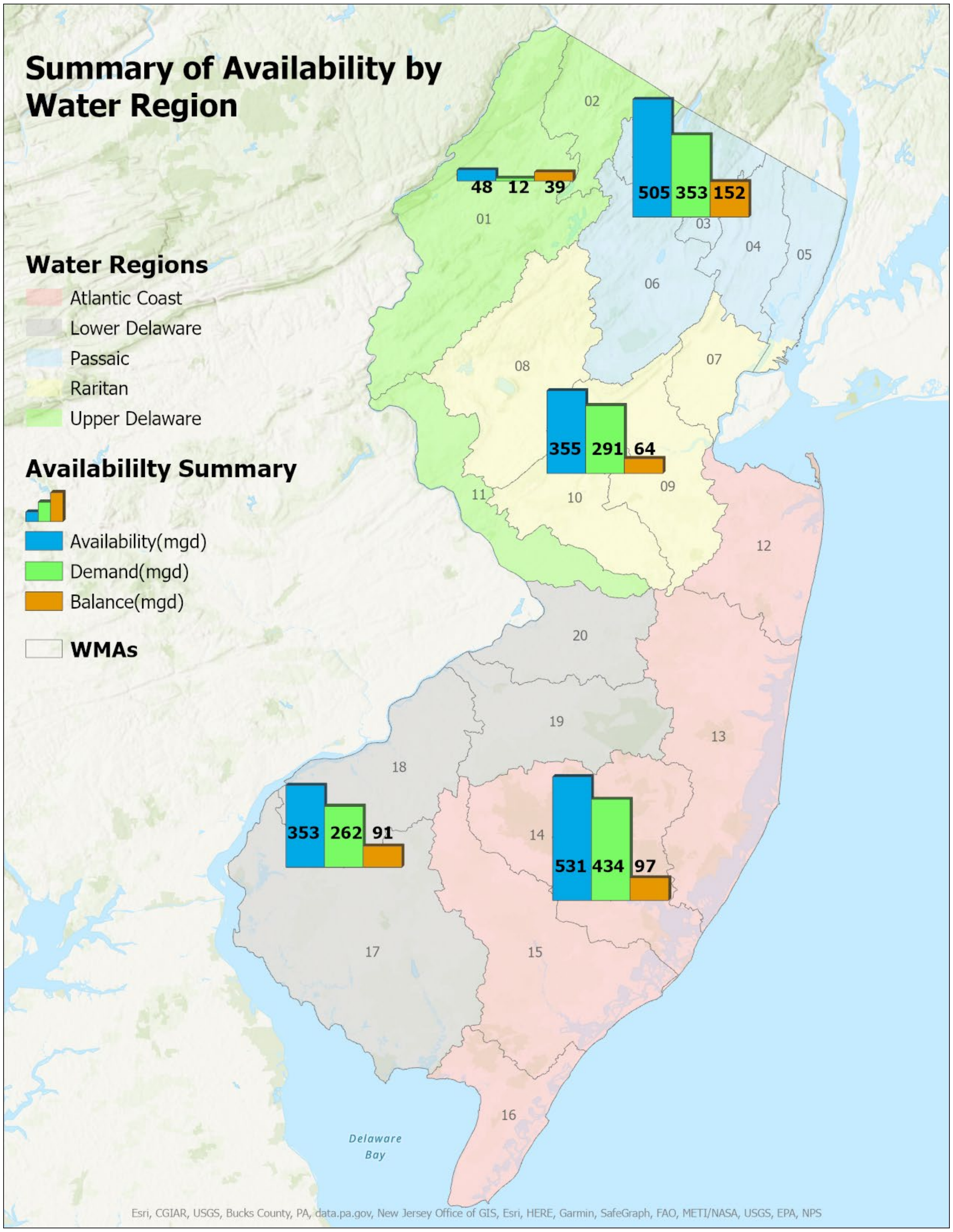

Figure 4.24 Shows WMA natural availability, demand, and remaining availability (balance) collapsed to water region.

Figures 4.25-4.29 contain the availability data from Figure 4.24 but display it in greater detail. Each chart depicts the summary for a single Water Region and breaks down the availability, demand, and balance data by WMA. Within each WMA, the amount of water contributed by reservoirs, unconfined groundwater and surface water, and confined groundwater is shown. In some cases, there is a deficit for a given resource, most frequently unconfined groundwater and surface water, in a WMA denoted by a negative value in the balance column. However, Figure 4.24 shows that when data is summarized by Water Region, no deficits are present. A negative value in the demand column occurs when water returns for a given resource are larger than the withdrawals.

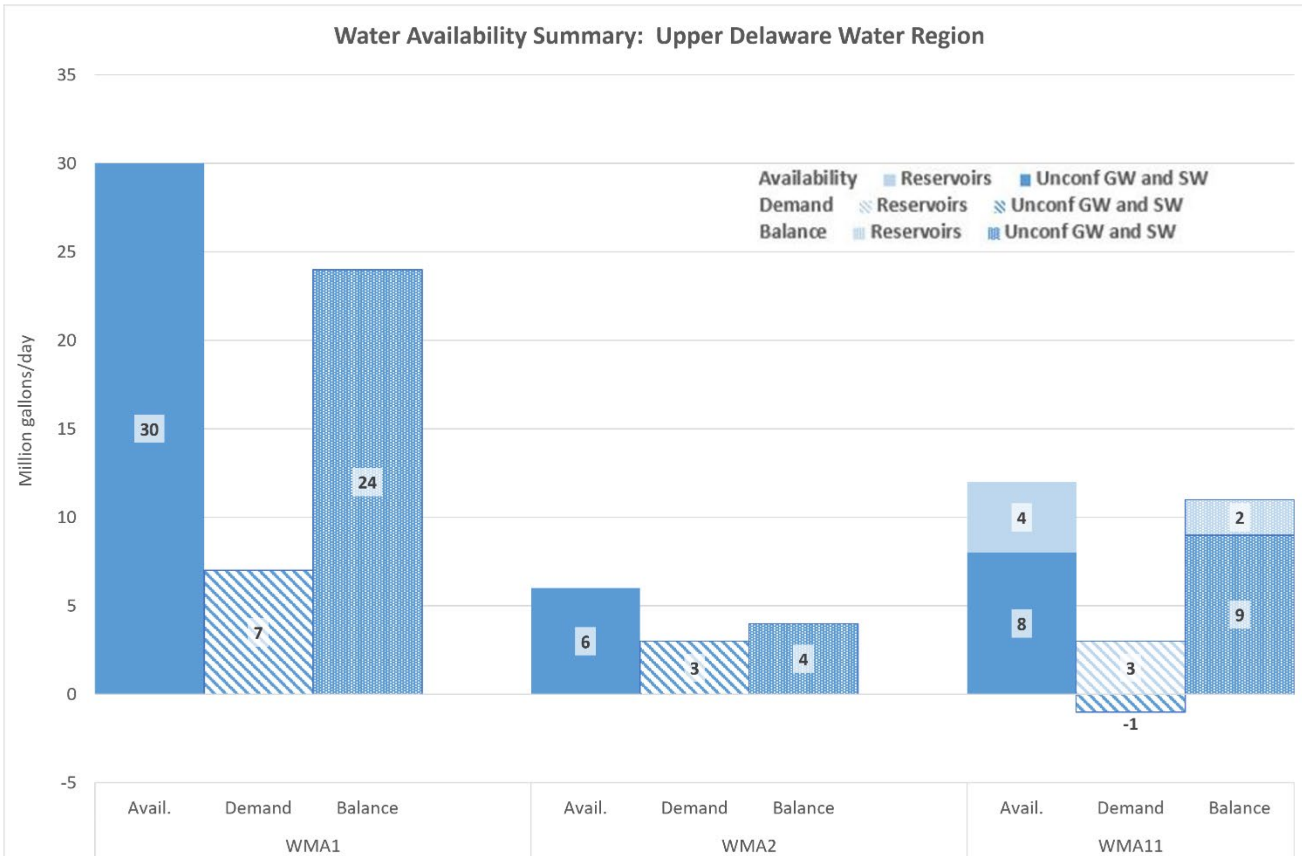

Figure 4.25 Water availability summary for the Upper Delaware Water Region availability, demand, and the resulting balance for each WMA in the region are categorized by resource.

The Upper Delaware Water Region is comprised of three WMAs within which, unconfined groundwater and surface are the primary resources. As shown in Figure 4.25, none of these WMAs holds a negative balance, due in large part to relatively low demands.

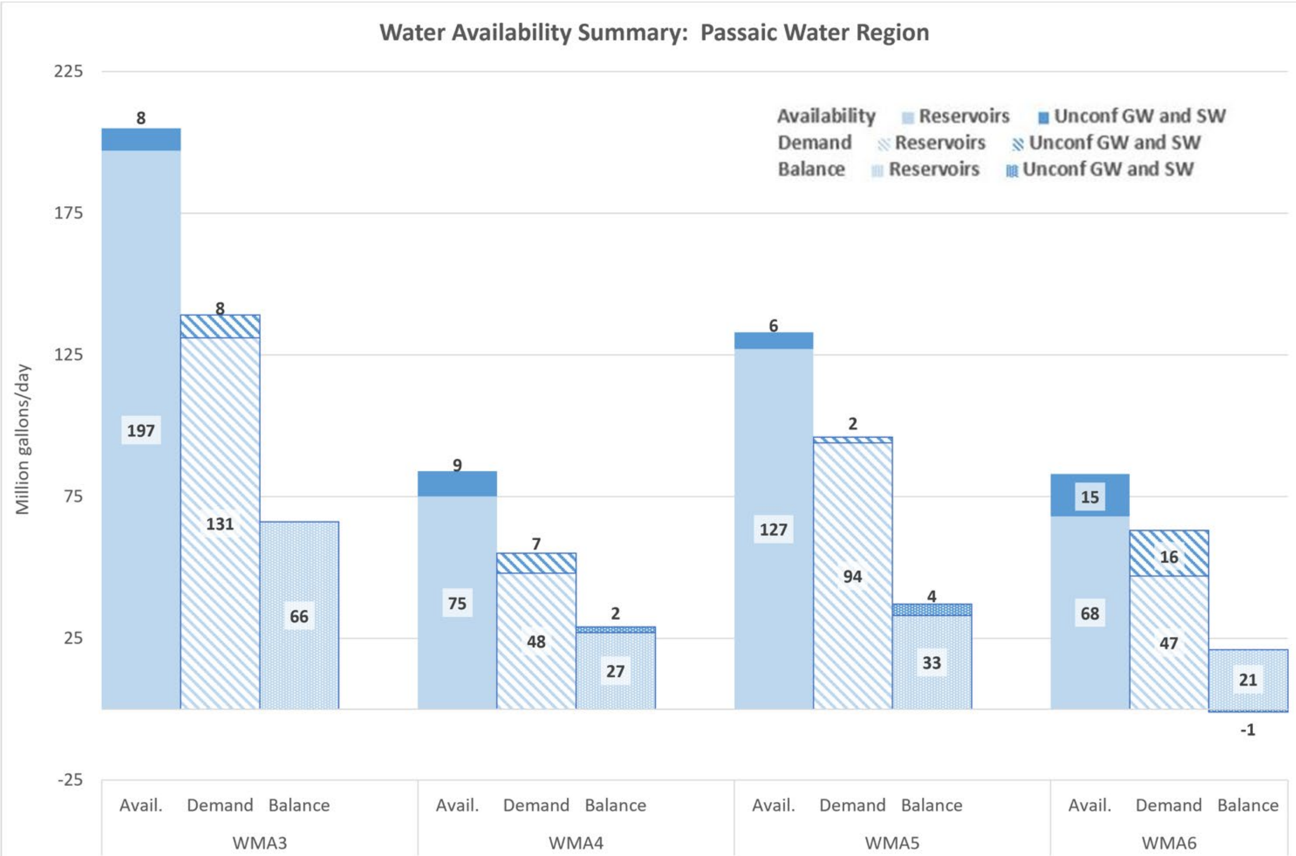

Figure 4.26 Water availability summary for the Passaic Water Region availability, demand, and the resulting balance for each WMA in the region are categorized by resource.

Reservoirs serve as the primary resource for the Passaic Water Region's four WMAs, although there is some unconfined groundwater and surface water use as well. All WMAs have positive balances for reservoirs, and in WMA 6 unconfined groundwater and surface water demand is slightly higher than availability.

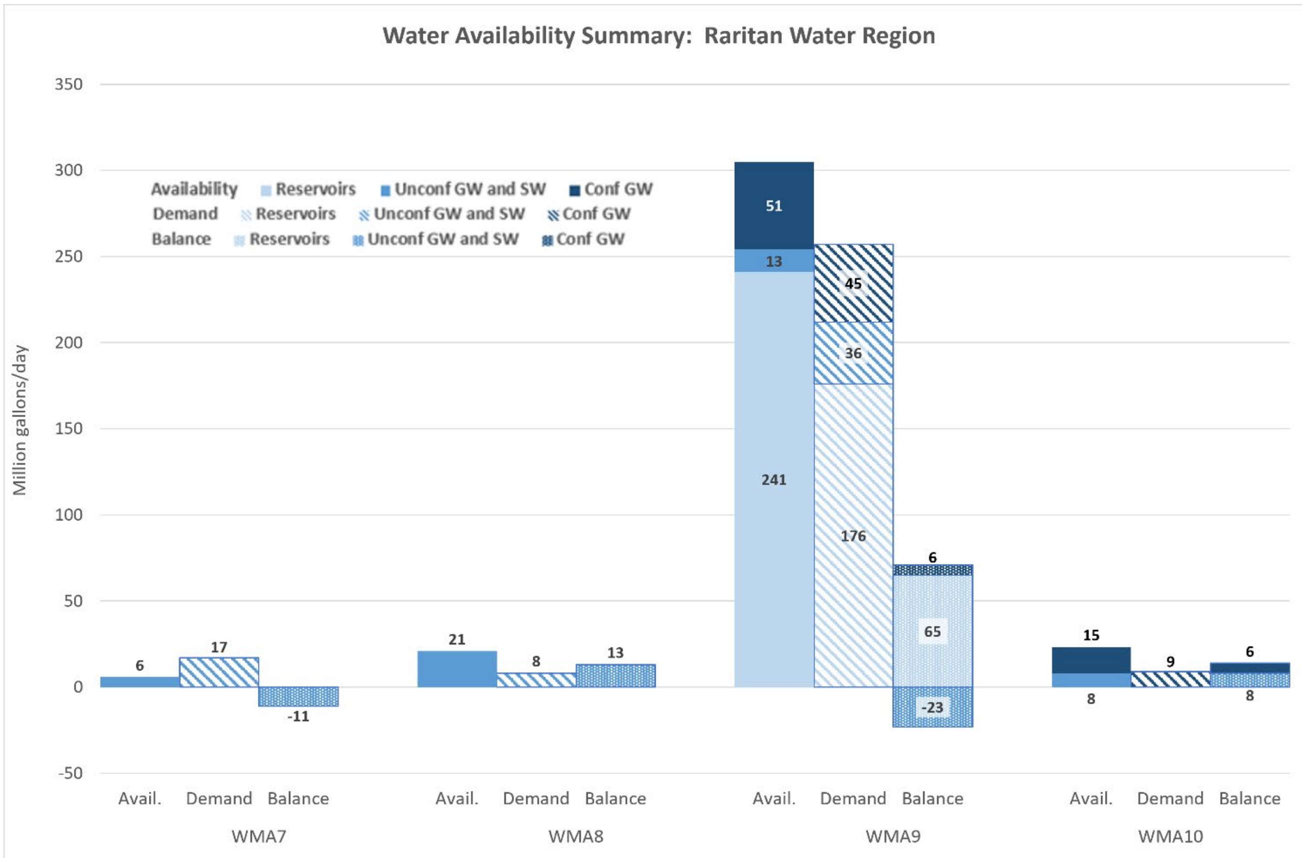

Figure 4.27 Water availability summary for the Raritan Water Region availability, demand, and the resulting balance for each WMA in the region are categorized by resource.

The Raritan Water Region contains four WMAs, of which WMA 9 has the greatest availability and demand, dominated by reservoir supply. Demand for unconfined groundwater and surface water outweighs availability in WMAs 7 and 9.

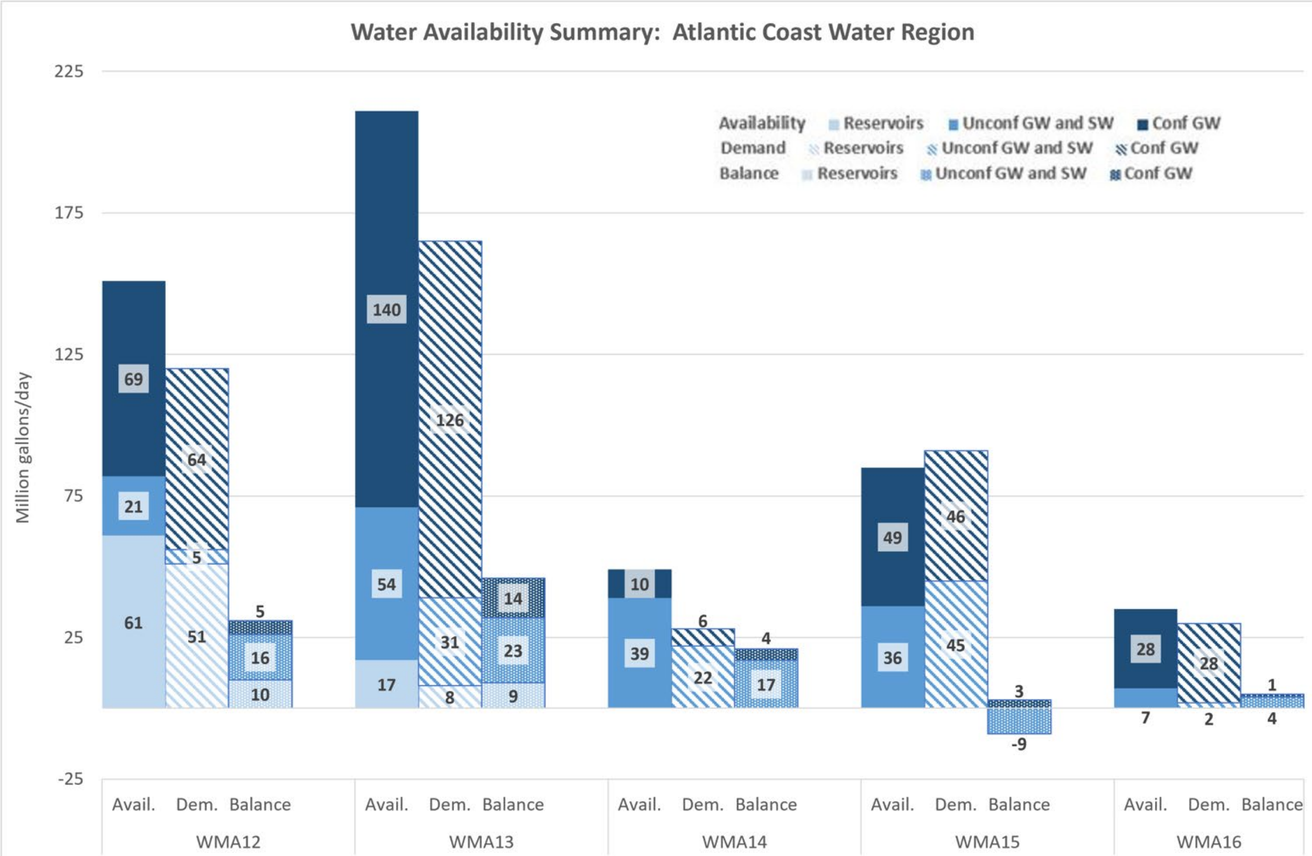

Figure 4.28 Water availability summary for the Atlantic Coast Water Region availability, demand, and the resulting balance for each WMA in the region are categorized by resource.

The Atlantic Coast Water Region shows significant use of all three resources with a greater reliance on confined groundwater than the other Regions. WMA 15 has a negative value for balance in the unconfined groundwater and surface water category.

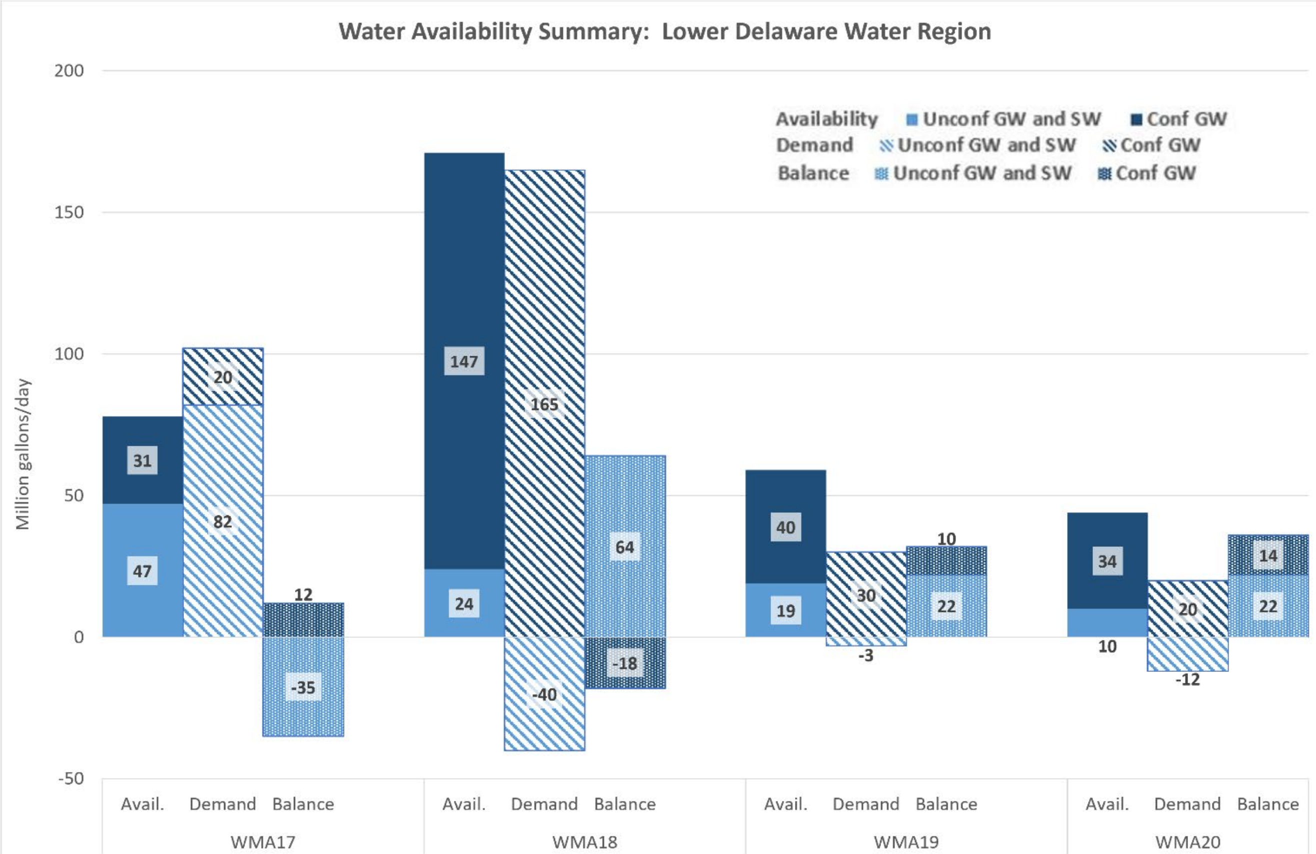

Figure 4.29 Water availability summary for the Lower Delaware Water Region availability, demand, and the resulting balance for each WMA in the region are categorized by resource.

In the five WMAs in the Lower Delaware Water Region, unconfined groundwater and surface water and confined groundwater are the relied-upon resources. Negative balances occur for unconfined groundwater and surface water in WMA 17 and for reservoirs in WMA 18.

SUMMARY

In summary, most PCWS have sufficient permitted capacity to meet demands to the year 2050 if they successfully control water losses and anticipated water use efficiencies are achieved. However, even with these water savings, some PCWS may need additional supplies, either from existing bulk purchase contracts or local sources.

The analyses for water resources suggest current water resources are sufficiently available however, in light of changing climate several regions need to be further assessed and monitored to ensure that the stresses under full allocation scenarios are not realized. Some resources either are or may be stressed currently, based on preliminary information (e.g., the LFM approach) or detailed models (e.g., confined aquifers, reservoir safe yields). The relative demands by use category vary widely; no single approach will be useful in all regions. In many areas, more detailed information will be needed to verify water stresses. However, in some of these regions, the calculated stresses are so high that a high level of scrutiny is

required to reduce consumptive and depletive losses from current uses and likely to restrict increased demands; this step has been taken already in several regions, as discussed in Chapter 6 on regional planning.

The detailed water assessments and potential management options are covered in the following chapters and provide a framework to inform future decisions regarding water supply. Users looking for availability at a specific location should be aware that site-specific conditions may be more limiting than the WMA-wide analysis might indicate.

Two specific areas DEP intends to target related to statewide demands and balances include:

- continued efforts in its proposed rulemaking to codify the Water Quality Accountability Act to require applicable PCWSs to conduct and submit an annual AWWA Water Loss Audit; and
- further actions to decrease uncertainty in current water balance estimation methods, including:
  - monitoring and updating statewide water data;
  - reviewing alternative region-specific sustainability thresholds; and
  - periodic updating of water availability and forecast analyses.

CHAPTER 5: WATER RESOURCE PROTECTION AND PLANNING EFFORTS

TABLE OF CONTENTS

OVERVIEW

The DEP has the primary responsibility for managing New Jersey's water resources. This includes the protection of water supplies and quality, allocation to users, infrastructure regulation and financial assistance, and the assurance of safe drinking water. Due to this broad responsibility, DEP has focused its efforts on comprehensive water resources management -- a holistic approach to managing the State's water resources from the perspective of supply, quality, standards, and monitoring. DEP operates under both general and specific legislative authorities and under defined principles and priorities (About DEP website).

Whitesbog Village Historic Site located in Brendan T. Byrne State Forest in the New Jersey Pine Barrens.

This chapter details how DEP comprehensively manages New Jersey's water resources and notes areas where future work will expand on current approaches. Key items addressed include program areas devoted to the protection of New Jersey's water resources, water efficiency and conservation strategies, and water system resilience and asset management. These areas directly relate to discussions of environmental justice in water resources. This is a new topic area for this Plan building off New Jersey's recently passed Environmental Justice Laws, some of the most progressive in the nation. This chapter includes an analysis of environmental justice concerns as they relate to water supply in overburdened communities and sets up the necessary groundwork for ways in which DEP can continue to address environmental justice in water resource management and drinking water protection.

The Division of Water Supply and Geoscience's safe drinking water program's function and mandate is also covered in this chapter, along with a statewide assessment of the water systems operating throughout New Jersey, the latter being a new topic not previously covered in past water supply plans. DEP recognizes that water quality can have serious impacts to overall supplies. Some of the ways in which DEP performs continuous monitoring and assessment of New Jersey's water resources are also described here and noted as vital areas for continuous efforts.

Finally, the waters of New Jersey are managed by several regional water resource agencies in addition to but with similar missions to those of DEP. These include the Delaware River Basin Commission, the Pinelands Commission, and the Highlands Commission. The permitting and planning practices of these agencies are detailed to provide an expansive view of water resources management occurring throughout the state.

This Plan, and specifically this chapter, outlines the range of actions DEP is actively undertaking to ensure an adequate supply of properly treated water is available throughout New Jersey. DEP will continue to focus on safeguarding source water, addressing threats to drinking water quality and infrastructure, and furthering its commitment to environmental justice in water resources. Lastly DEP would like to note that the New Jersey Office of Planning Advocacy has recently initiated a process to update the State Plan, last released in 2001. The State Plan has cross acceptance procedures to coordinate water supply and other state plan actions across numerous state agencies. DEP is a participant in the cross-acceptance process to ensure coordination between the policies of the State Plan and the Plan More information can be found here: Office of Planning Advocacy State Plan website.

Topics found in this chapter relate to other areas of the Plan where additional detail can be found. Readers are encouraged to visit the following:

- Climate change impacts that relate to many of the concepts covered in this chapter are explored in Chapter 3.
- Greater detail regarding many planning and policy efforts can be found in Appendix L.
- Water allocation regulations and permitting programs are discussed throughout this Plan, specifically in Chapter 2 (overall program), Chapter 4 (statewide water availability), and Chapter 6 (regional issues).

PROTECTING NEW JERSEY’S WATER RESOURCES

DEP has taken significant steps to improve the protection of New Jersey’s water resources, including source water assessment and protection, land preservation, improved surface water quality standards and regulations related to water supply, point source pollution controls and stormwater management. DEP continues to be actively engaged in the management of the State’s drinking water sources for both quantity and quality. Historically, the primary purpose of the New Jersey Statewide Water Supply Plan was to focus on the quantity of available water, both current and future needs. DEP recognizes that the supply of adequate safe and reliable water cannot be fully assessed by evaluating quantity alone and has greatly expanded its analysis of drinking water quality and water supply infrastructure in this Plan. To understand the State’s vulnerabilities, the Plan must consider the impacts of aging infrastructure, emerging contaminants, and climate change. These factors are significant in determining the future water supply conditions for New Jersey.

WATER QUALITY REGULATORY PROGRAMS

The quality of the water resource is an equally important component and DEP has numerous programs devoted to preserving and restoring the water quality of New Jersey's aquatic resources. In general, New Jersey's water quality has been improving since the 1970s, mainly due to DEP's focus on achieving better wastewater treatment and focus on non-point source pollution. The net impact of this improvement is effectively summarized in the most recent version of the New Jersey Integrated Water Quality Assessment Report series, available at Water Quality Assessment. These reports "provide effective tools for maintaining high quality waters and improving the quality of waters that do not attain their designated uses." They show not only the ways in which the DEP has sought to implement improvements from point source controls, but also areas of potential concern where the long-term trends point toward increasing nonpoint source pollutant concentrations, including nutrients that can trigger harmful algal blooms (cyanobacteria blooms) and chloride levels from road salts, that are related to the long-term trend of suburban and exurban development.

Water quality monitoring, assessment, and restoration is an ongoing process. The DEP has rules and regulations to help protect and improve water quality, including:

- Discharges of Petroleum and Other Hazardous Substances (N.J.A.C. 7:1E);
- Coastal Zone Management Rules (N.J.A.C. 7:7);
- Freshwater Wetland Protection Act Rules (N.J.A.C. 7:7A);
- Stormwater Management Rules (N.J.A.C. 7:8);
- Standards for Individual Subsurface Sewage Disposal Systems (N.J.A.C. 7:9A);
- Surface Water Quality Standards (N.J.A.C. 7:9B);
- Ground Water Quality Standards (N.J.A.C. 7:9C);
- Well Construction and Maintenance; Sealing of Abandoned Wells Rules (N.J.A.C. 7:9D);
- Private Well Testing Act Rules (N.J.A.C. 7:9E);
- Safe Drinking Water Act Rules (N.J.A.C. 7:10);
- Flood Hazard Area Control Act Rules (N.J.A.C. 7:13);
- Water Pollution Control Act Rules (N.J.A.C. 7:14);
- Pollutant Discharge Elimination System Rules (N.J.A.C. 7:14A);
- Sludge Quality Assurance Rules (N.J.A.C. 7:14C);
- Underground Storage Tank Rules (N.J.A.C. 7:14B);
- Water Quality Management Planning Rules (N.J.A.C. 7:15);
- Water Supply Allocation Permits (N.J.A.C. 7:19);
- Agricultural, Aquacultural and Horticultural Water Usage Certification (N.J.A.C. 7:20A);
- Industrial Site Recovery Act Rules (N.J.A.C. 7:26B) and Remediation Standards (N.J.A.C. 7:26D);
- Pesticide Control Code (N.J.A.C. 7:30);
- Highlands Water Protection and Planning Act Rules (N.J.A.C. 7:38);
- Green (and Blue) Acres Program (N.J.A.C. 7:36); and
- Site Remediation Rules (N.J.S.A. 58:10 et seq).

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SOURCE WATER ASSESSMENT PROGRAM

In 2004, as a requirement of the 1996 Amendments to the Safe Drinking Water Act, DEP, in conjunction with the United States Geological Survey (USGS), performed source water assessments for all public community water systems (PCWS) and public non-community water systems (PNCWS), to predict the susceptibility of source water to contamination. While many regulatory programs were in place to protect the quality of drinking water, the results of the Source Water Assessment Program (SWAP) were designed to provide planning opportunities to: (1) determine the source water assessment area of each ground and surface water source of public drinking water; (2) develop an inventory the potential contamination sources within the source water assessment area; (3) determine the public water system source's susceptibility to regulated contaminants; and (4) to incorporate public education and participation. Source water assessment reports for each of the approximately 600 community water systems and 3,545 non-community water systems were completed and released on the SWAP website. These reports provide information on the potential vulnerability of each of the water system's sources to the following contaminant categories: nutrients (nitrates), pathogens, pesticides, volatile organic compounds (VOCs), inorganics (metals), radionuclides/radon, and disinfection by-product precursors. See Figure 5.1 for a map of surface water source areas.

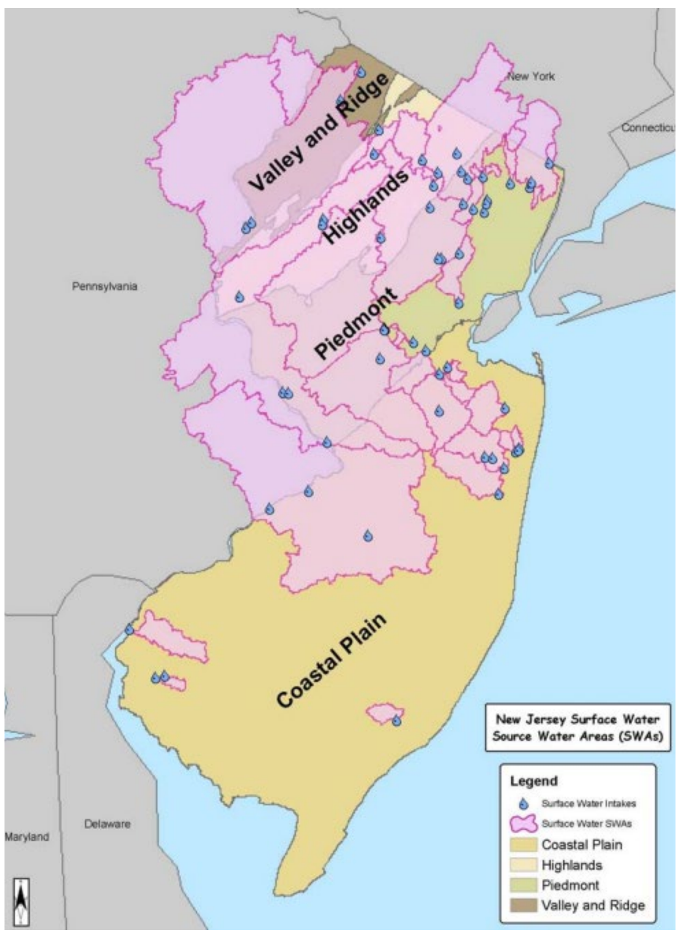


Figure 5.1 Surface water source water areas from the 2004 New Jersey Source Water Assessment Program Statewide Summary report.

As part of the Source Water Assessment Program, DEP also developed well head protection areas (WHPA) for PCWS and PNCWS water supply wells. Well head protection areas are calculated in accordance with the Guidelines for Delineation of Well Head Protection Areas in New Jersey and delineate the horizontal extent of ground water captured by a well pumping at a specific rate over a two-, five-, and twelve-year period. The well head protection areas provide a critical component of the source water assessment and protection activities as well as the basis for focusing efforts of the state's groundwater protection strategy. These resources require periodic update to reflect new or modified sources or the improved location of existing wells. Additionally, improved hydrogeologic properties will change the extent of each well's WHPA. Periodic revision of these areas is also required.

The reports and supporting documents are available to the public by searching for water systems at: SWAP Reports & Summaries. While some systems have changed names or ownership over time, the reports still have value, but ultimately should be updated on a periodic basis to reflect current data, policies and issues.

These Source Water Assessments highlighted the importance of regulating land use activities in order to protect sources of potable supply for both ground and surface water resources. As part of its larger drinking water quality protection efforts, DEP is developing an expanded and more integrated Source Water Assessment process. This process will utilize updated potable source location data, consider recently added MCLS, emerging contaminants (e.g., chloride and sodium from winter salting applications), and take advantage of the improved GIS utilities that are now available to the DEP. The revised program is also envisioned to integrate the goals of the SWAP into some of the established water quality protections programs that are active in the DEP. These may include the C1 waters designation, the Integrated Water Quality Assessment Report, Water Quality Management Plans, or the State Plan. For example, the source water assessment plans may identify a water system that serves less than 100,000 people which would benefit from C1 designation and its associated regulatory protections. In such cases the revised SWAP could inform C1 designation criteria so any drinking water system that could benefit from upstream land use and wetland protections could benefit from the program. There are also potential C1 designation restrictions which can limit a water utility's ability to repair, expand or enhance infrastructure (such as changes needed to meet new MCL standards or to make infrastructure more resilient to the threats from climate change, or simply to maintain and repair critical infrastructure) that can be addressed by this enhanced SWAP process. Additionally, the program could identify specific drinking water quality parameters or metrics that could be used to define non-degradation criteria. Similarly, the SWAP may identify surface watershed or groundwater recharge areas that need to be considered when Water Quality Management Plans are amended. Details of the enhanced SWAP are forthcoming.

CATEGORY ONE (C1) WATERS

The Surface Water Quality Standards (SWQS) at N.J.A.C. 7:9B require that any water bodies that are designated as Category One (C1) waters be protected from any measurable change in water quality because of their exceptional ecological, recreational, water supply, or fisheries resources significance. Through these regulations, C1 designation provides additional protection to water bodies that help

prevent water quality degradation and discourage development where it would impair or destroy natural resources and environmental quality. The maintenance of water quality is important to all residents, particularly to the many communities that depend upon surface waters for public, industrial, and agricultural water supplies, recreation, tourism, fishing, and shellfish harvesting. The C1 Story Map and some of its infographics provide details on the C1 designation and its evolution since inception in 1981.

Both the 1996 and 2017 New Jersey Statewide Water Supply Plans proposed a better integration of New Jersey's SWQS with surface water supply management, including an evaluation of the surface water use designations and water quality criteria with respect to their adequacy to protect surface water supplies. As discussed above, this Plan is also recommending further integration.

As of April 2020, DEP had designated around 7,400 stream miles and 12,374 acres of lakes and reservoirs as C1 waters. Most of these designations were made in 1985 based on State and Federal parks, wildlife management areas, and trout production waters. Between 1985 and 2002, only streams upgraded to Fresh Water Two (FW2) trout production, achieved C1 designation. In 2002, DEP began an intensive effort to identify additional waters that warranted enhanced protections afforded by this designation. Starting in 2002, DEP expanded the C1 designation criteria to include waters of "exceptional ecological significance" and of "exceptional water supply significance." A 2008 rule added 686 miles of C1 waters (mostly for exceptional water supply significance), and in 2020 DEP adopted new C1 designations affecting 600 miles of streams (mostly for ecological significance).

The designation of these waters as C1 is a preventive measure aimed at protecting waters that are ecologically exceptional and/or drinking water sources. Land use and wastewater infrastructure decisions associated with C1 waters are required to meet the anti-degradation policies specified in the SWQS. This preventive strategy serves to substantially enhance protection for one-half of the State's drinking water supplies. DEP is working to re-evaluate the criteria for designating C1's under water supply significance.

For more information pertaining to C1 Waters, please see the Division of Water Monitoring, Standards, and Pesticide Control web site at: C1 Waters.

WATER QUALITY MANAGEMENT PLANNING (WQMP)

The Water Quality Management Planning (WQMP) rules, N.J.A.C. 7:15, implement the Water Quality Planning Act (WQPA), N.J.S.A. 58:11A-1 et seq., whose purpose is to maintain and, where attainable, restore the chemical, physical, and biological integrity of the surface and ground water resources of the State. The WQMP rules are one component of the State's water quality continuing planning process (CPP) required by Sections 201, 208 and 303 the Federal Water Pollution Control Act, 33 U.S.C. §§ 1251 et seq. (33 U.S.C. §§ 1281, 1288, and 1313), commonly known as the Clean Water Act (CWA), as well as the State WQPA and the Water Pollution Control Act (WPCA), N.J.S.A. 58:10A-1 et seq. The CPP is intended to integrate and unify water quality management planning processes, assess water quality, establish water quality goals and standards, and develop a Statewide implementation strategy to achieve the water quality standards. The WQMP rules provide a framework to integrate wastewater planning with existing permitting programs. They also provide the framework to identify the anticipated municipal and industrial

waste treatment needs and any gaps in providing capacity in the future. More information is at Water Quality Management Planning Program.

Currently, the WQMP process does not take into consideration water supply availability when making decisions. This review was previously completed but was subsequently ceased due to rule change. Disconnecting water quality decision making from water supply can lead to water resource management problems. DEP should work to re-implement water supply reviews into WQMP decision making processes.

WETLANDS IMPACTS REVIEW IN ALLOCATION PERMITTING DECISIONS

Following a 2009 Appellate Division decision regarding an appeal of amendments to the rules for Agricultural, Aquacultural, and Horticultural Water Usage Certification at N.J.A.C. 7:20A, DEP determined it would cease its cross-programmatic review (pursuant to the rules for Water Supply Allocation Permits at N.J.A.C. 7:19; Water Resource Management and Watershed and Land Management) of impacts to wetlands stemming from proposed diversions greater than 100,000 gallons per day. Since it is well documented that water diversions located outside of wetlands and transition areas have the potential to adversely impact wetlands, including groundwater dependent flora and fauna, DEP will explore legal and regulatory options for restarting and formalizing a cross-programmatic review process.

WATER USE EFFICIENCY AND CONSERVATION

Improving water use efficiency and decreasing water waste is one of the most cost-effective and environmentally sound planning methods to decrease water resource demands. Increasing water efficiency improves DEP's water management approach in several ways. First, it helps to improve statewide capacity for responding to future uncertainties, such as changes in population, the potential for hotter, more erratic weather, and increased outdoor water use and consumptive water losses. Second, water efficiency and conservation methods can help to reduce the need for future additional expenditures for treatment, distribution, and storage infrastructure by decreasing future water supply needs. Third, water not needed due to improved efficiency and conservation ensures more water is available for ecological and recreational use, along with the potential for storage for future use.

DEP continues multiple initiatives to increase water efficiency with the goal of averting future water emergencies and potential needs for water use restrictions or other costly measures during drought or other emergency conditions. Initiatives taken by DEP can be categorized as both demand/source management and statewide water conservation strategies, which are described below with greater detail provided in Appendix L.

DEMAND/SOURCE MANAGEMENT

A key feature of the New Jersey Statewide Water Supply Plan is to curtail water waste and extend New Jersey's water supplies into the future, reserving high quality waters through both source and demand

management. This approach ensures that DEP can pursue water conservation and efficiency strategies by targeting the state's largest water uses.

Two trends were detected in statewide water demand and use analyses that guided the discussion of current DEP water conservation actions in the next sub-section. The first trend is the decrease in statewide water demand for power generation. This is primarily due to the closing of coal-fire power generation plants, which use more water, and replacing them with gas-fired plants equipped with more efficient cooling technologies (with the larger statewide goal of switching to renewable sources of power such as offshore wind). The second trend is the more critical issue of increasing consumptive water losses, which has primarily occurred in the public water supply and non-agricultural irrigation sectors. Specifically, these water uses include activities such as outdoor lawn/landscape irrigation, recreation, and household maintenance, which tend to be highest during peak summer months when water natural resource and treated drinking water supplies are usually the most stressed.

STATEWIDE WATER CONSERVATION STRATEGIES

Six categories of current DEP actions to promote statewide water conservation were used to form DEP potential policy options discussed in Appendix L. These actions primarily target the potable supply sector, specifically the outdoor "non-essential" or "non-potable" uses such as lawn/landscape watering, which was identified as the single greatest source of State consumptive water loss. Agricultural demands are also discussed, since they can stress local water supplies in locations where agricultural irrigation is a significant portion of demands. Each of the six categories of current DEP actions to promote statewide water conservation are provided below.

- Public Education and Outreach: DEP has developed and implemented different approaches to inform the public about water supply issues, drought management, and water conservation and efficiency strategies- DEP Water Conservation. Examples of water conservation programs DEP has implemented include the New Jersey Water Savers program and the Water Champions program. DEP also continues to promote statewide water conservation and efficiency through involvement in the Sustainable Jersey program and the Environmental Protection Agency's (USEPA) WaterSense program. Tailored programs may also need to be developed to address community or region specific issues; e.g. OBCs or vacation/shore communities
- Reduce Non-revenue Water Losses and per Capita Water Usage: Non-revenue water (previously referred to as unaccounted-for water) refers to water withdrawn from a source by a purveyor and is not accounted for as being delivered to customers in a measured amount. This water contributes to overall water loss – a critical problem as greater water losses increase the amount of water withdrawn from reservoirs, rivers, and aquifers, placing greater stress on these resources. Since April 2017, DEP has worked to monitor water loss data through an electronic portal, including larger systems that are interconnected and serve at least 1,000 people. In addition, DEP regulations subject New Jersey public water systems to water loss requirements and expectations and use a metric that considers all types of non-revenue water, whether real (i.e., system leakage, hydrant flushing, etc.) or apparent (i.e., meter errors, theft, etc.). DEP is also encouraging the use of a more detailed system of measurement, the Water Audit program of the

American Water Works Association (AWWA) (more information is available at DRBC Water System Audits), which the Delaware River Basin Commission (DRBC) requires for all public water suppliers in the Delaware River Basin. At this time, DEP does not require AWWA audits to be submitted by most systems outside of the DRBC's authority. However, pending rulemaking from DEP to fully implement the Water Quality Accountability Act (WQAA) would require approximately 300 PCWSs to complete the American Water Works Association water loss audit. This increase in access to water loss data would improve DEP's ability to identify systems with excessive water losses.

- **Reduce Excessive Outdoor Water Use**: Residential and commercial landscaping contributes to the increased consumption of potable water supplies, especially during the peak use growing season. It increasingly strains surface and groundwater water resources, drinking water treatment, and infrastructure capacity. DEP employs several different strategies to reduce excessive outdoor water use.
    - **Residential Irrigation Water Scheduling and Use of Smart Irrigation Controllers**: DEP has partnered with Sustainable Jersey to create an Outdoor Water Conservation model ordinance for municipal consideration. This ordinance recommends a two-day-per-week water schedule, with an exception for properties with Smart irrigation controllers. While historically many water utilities have used every-other-day watering restrictions, in practice this tends to result in increased water usage than if restriction were not in effect. Instead, two-day per week restrictions tend to result in the desired demand reductions, while still affording residents some flexibility in maintaining their outdoor landscaping. This ordinance is promoted as a Priority Action Item in the Sustainable Jersey program, under the Water Conservation Ordinance Action.
    - **Agricultural Irrigation System Technologies**: DEP is working to better understand water use measurements of agricultural irrigation and promote the lowest quality water for intended use. DEP in collaboration with the U.S. Geological Survey, New Jersey Department of Agriculture, and Rutgers Agricultural Experiment Station developed a pilot project to compare irrigation volumes using standard estimation methods (calculation-based method) versus two types of flow meters. Agricultural water use issues and the results of this study are also discussed in Appendix L and Chapter 6 for regions where it is the dominant water use.
    - **Residential Rainwater Harvesting**: DEP also works with the Watershed Ambassadors program to continue a residential rainwater harvesting program (rain barrels and rain gardens) that was begun in 2000. Designed to promote the lowest quality water for intended use, to date over 2500 rain barrels have been built and distributed statewide. Each barrel mitigates approximately 1400 gallons per year for a total of 3.5 million gallons annually statewide.
- **Rate-making and Billing**: Water conservation-minded rate structures are designed to motivate consumers to decrease excess water usage. However, while conservation rate structures can be effective to reduce water demands, improperly set rates may lead to unexpected demand changes that can positively or negatively affect water supplier revenue. The Board of Public Utilities (BPU), the New Jersey Department of Community Affairs (NJDCA), municipal systems,

and privately owned purveyors (a) evaluate water conservation rates and water pricing systems that encourage water conservation, and (b) allow for a recovery of conservation program costs through water sales. Potential conservation rate structures that can be used include block rates, seasonal rate structures, and decoupling rate structures. DEP supports the efforts of these agencies in their evaluation and application of these rate structures wherever prudent. Additionally, prior to instituting conservation rate structures it is also important that affordability be considered with respect to income in the service area. Specifically, potential impacts to overburdened communities should be assessed. In some of these communities' rates may already be high when viewed in comparison to average income and institution of conservation rates could potentially exacerbate this situation.

- Indoor Plumbing and Appliances: Encouraging high efficiency household appliances can help decrease future potable water demands. Potential ways of increasing indoor plumbing efficiency include the adoption of advanced meter technology, the use of home water audits, and the development of plumbing retrofit ordinances and programs. In 2021, Governor Phil Murphy signed into law P.L. 2021, c. 464, establishing minimum efficiency standards for several types of residential and commercial appliances. This law applies to appliances such as spray sprinkler bodies, toilets, urinals, faucets, and showerheads. Additional information about this is available here.
- Reclaimed Water for Beneficial Reuse (RWBR): "RWBR involves taking what was once considered waste product, giving it a specialized level of treatment and using the resulting high-quality reclaimed water for beneficial use. In other words, the reclaimed water is used to replace or supplement a source of groundwater or potable water" (DEP, 2005). The importance of RWBR as a water management tool first emerged during the drought conditions of 1999 and the subsequent 2002 drought event. RWBR in New Jersey continues to gain ground as a viable and attractive water source alternative for specific purposes to help meet future water demands. RWBR applications must be sent to the DEP for approval, to ensure among other things, RWBR does not divert critical streamflow waters necessary for the health of aquatic ecosystems. DEP increasingly advocates for the use of RWBR as a drought mitigation strategy and long-term water supply management tool, particularly for highly consumptive, non-potable purposes. DEP will study further revisions to the DEP Water Allocation Rules to discourage new or increased non-potable, highly consumptive allocations, except as possible sources of back-up emergency supplies to RWBR. To promote RWBR, DEP has instituted financial assistance programs to assist the financing of new infrastructure and additional treatment requirements for RWBR projects. More information regarding RWBR can be found at the DEP RWBR website.

WATER SYSTEM RESILIENCE AND ASSET MANAGEMENT

A critical challenge of statewide water management planning is ensuring water systems can provide sufficient water during and after emergencies, such as water main breaks and severe weather events and the ability to adapt to challenges that arise as the result of climate change. The Water Quality Accountability Act of 2017 (WQAA) was adopted in response to aging water infrastructure and final recommendations by the New Jersey Joint Legislative Task Force on Drinking Water (2018). The WQAA establishes a formal framework for the asset management requirements for applicable water systems, which includes both treatment and delivery components. In addition to ensuring water systems ability to maintain and invest in their systems to guarantee the delivery of safe drinking water, it is key that systems be able to provide an adequate volume of water to their customers during emergencies, including drought. This may require both internal and external resources and strategies, such as adequately functioning system interconnections, access to proper storage, conjunctive water use, Managed Aquifer Recharge (MAR), and substitution of water resources. Exploration of new or potential expanded sources of supply may also assist PCWS to reduce the potential stress of meeting future water demand. Success in meeting these challenges hinges on proper investment by each system. This includes but is not limited to ensuring proper rate structure is in place, the use of bonds, and taking advantage of low interest loans such as those available through the Drinking Water State Revolving Fund where feasible.

The Delaware and Raritan Canal (Feeder Canal) in Mercer County.

DEP WATER SYSTEM RESILIENCE ACTIONS

Different categories of current DEP actions related to improving statewide water system resilience are provided below. Examples of resilience include preparedness, maintenance, and regular capital investment to address current conditions as well as those expected with future climate conditions. Each of these topics and potential management options associated with them are discussed in greater detail in Appendix L. Additional information and analysis related to water supply climate resilience is covered in Chapter 3.

- Promote Water System Resilience and Emergency Planning: To promote water system infrastructure resilience after Superstorm Sandy, DEP required water systems to submit their Emergency Response Plans (ERPs) in accordance with N.J.A.C. 7:19-11.2. Guidance was developed

to enhance the development of the ERPs around four major themes (Flood Protection, Asset Management, Emergency Management Planning and Preparedness, and Auxiliary Power), to ensure that future rehabilitation, repair, and construction of systems are conducted "safer, stronger, and smarter". DEP will continue to work with the drinking water sector to ensure it is prepared for extreme weather, implementing asset management, and dealing with emergencies.

- Additionally, in the summer of 2021, DEP required all surface water systems to submit addendums to their ERP's and include Cyanotoxin Management Plans to assess systems vulnerabilities and better prepare them in the event a HAB impacted their system.
- Emergency Agreements between Purveyors: DEP will also continue to monitor emergency agreements between purveyors. Emergency agreements allow systems to respond to either a potential for temporary system failure (e.g., a treatment plant issue or well failure) or meet a temporary need for water supply (e.g., drought). Existing Water Allocation rules at N.J.A.C. 7:19-6.9(g) (Operation of Interconnections) require DEP to provide approval of all emergency agreements. Additional approval by DEP must be provided through a water contract review application under N.J.A.C. 7:19-7 for interconnection operation agreements proposing routine purchase/sale or guaranteed firm capacity supplement.
- Water Supply System Interconnections: DEP continues to implement prioritized recommendations from the *2007 Statewide Interconnection Study*. DEP continues to use existing interconnected water systems to mitigate and avoid the negative impacts of drought and other water shortages, and is using the New Jersey River Model, Water Supply Management Decision Support Tool (WSMDT), and other equivalent tools to ensure data is kept current and to evaluate and facilitate proactive transfers. Recently, DEP has worked with the North Jersey District Water Supply Commission and Veolia Hackensack to modify normal operations of the Wanaque aqueduct to reduce the frequency of drought in the Northeast region.
- Surface Water Reservoir System Modeling: To determine the amount of water that can be routinely provided during a repeat of the drought of record, many reservoir-based water systems have developed safe yield models. Examples of two models developed to update safe yield estimates include one developed by the New Jersey Water Supply Authority for the Raritan System (uses the RiverWare modeling platform) and one by the North Jersey District Water Supply Commission for the Wanaque/Monksville System. DEP developed a water availability model using RiverWare for the Hackensack/Passaic/Raritan River Basins, which is used in water allocation reviews. DEP will expand its current model to address all surface water systems, including scenarios for finished water transfers and potentially to water quality issues. DEP will also continue to develop computer models to simulate water availability under different assumptions for regional and inter-regional water system groups.
- Implementation of Water Conservation and Drought Management Plans: Pursuant to N.J.A.C. 7:19-6.5(a)3, all water allocation permit holders are required to submit updated Water Conservation and Drought Management Plans (WCDMP). DEP will continue to enforce the requirements of existing rules to ensure that updates are accurate and implementable, and that drought management and response plans are up to date. DEP will also evaluate and review the efficacy of amending Water Allocation rules at N.J.A.C. 7:19-2.2(i) to enhance current WCDMP

forms with a new water audit and water loss program that includes best management practices and reporting requirements and is compatible with Delaware River Basin Commission requirements.

- Restructuring Water Allocation Regulations: Water supply emergency management procedures should continue to be streamlined to reorganize and consolidate existing rules that direct water supplies management during a water emergency, including the prioritization and restriction of water uses. DEP is currently considering amendments to the existing rules (N.J.A.C. 7:19) to reflect amendments to the Water Supply Management Act, provisions of the Highlands Water Protection and Planning Act, and the enactment of the Environmental Enforcement Enhancement Act. DEP is also considering proposed amendments to simplify the water emergency surcharge schedule, incorporate stakeholder input, increase flexibility, modernize and simplify business processes, and create consistency across DEP programs.
- General "Overdraft" Provisions: DEP will work with water supply purveyors to ensure that seasonal water and overdraft provisions are supported by safe yield models and guaranteed contracts between water purveyors but will make sure this does not adversely impact purveyors' abilities to meet demands.
- Competing Needs – System Investment and Water Affordability: In many cases, rates will need to rise to provide sufficient revenue for maintenance and capital improvements, which includes both personnel and structural assets. As a result, customers may be assessed increases to their bills, which can be financially stressful for lower-income households and businesses. For this reason, affordability will be an ongoing concern for many New Jersey areas and may potentially harm drinking water utilities that face strong opposition to rate increases, despite their asset management and improvement needs. DEP will continue to work to help mitigate affordability concerns.

INTERCONNECTIONS, CONJUNCTIVE USE, MANAGED AQUIFER RECHARGE, AND SOURCE SUBSTITUTION

Water supply systems can employ a variety of strategies to help reduce their vulnerability to drought and other seasonal shortages. These strategies include system interconnections, conjunctive use, managed aquifer recharge, and substitution of water sources. A description of each management strategy is included below, with further detail provided in Appendix L.

- **Water Supply System Interconnections:** The transfer of water between systems for routine or seasonal water supplies can offset supply risk and optimize the use of regional water resources (separate from emergency transfer issues). The *2007 Statewide Interconnection Study* also confirmed that interconnections are a valuable tool for alleviating regional drought conditions. However, while interconnections add to overall system reliability and resilience, it is important that the transferred water meets water quality standards, and that the resilience of the sending system is not harmed by the transfer. DEP will continue to work with purveyors to ensure any such problems are prevented or minimized. This includes evaluating and working to ensure that major interconnections between large systems such as those located in the northeast are

functioning and/or constructed if not available or that alternative and adequate supplies can be delivered to customers if a major pipeline from one purveyors treatment plant to the distribution area fails.

Related to this are PCWS without interconnections to neighboring systems or those geographically isolated and not able to interconnect. For these situations, the system needs to ensure that it has its own plans in place for any type of water supply emergency, i.e., drought or infrastructure failure. This could include alternative power supplies, emergency wells and intakes, adequate finished water storage, and plans in place to ensure that water quality is maintained. DEP will continue to work to identify these systems and work to ensure that appropriate plans are in place and that infrastructure is maintained.

- Conjunctive Use of Multiple Water Supply Sources: Conjunctive use can improve overall water supply reliability by providing several resources that can be strategically employed and rested based on different conditions, such as drought, peak seasons, or other water shortages. For example, a system may divert water from an unconfined aquifer during times of high availability and then rely on confined aquifers when temperatures, water use, and sparse precipitation could more adversely affect surface water sources. There are a variety of forms of conjunctive use including combined use of different surface water and confined and unconfined groundwater sources.
- Managed Aquifer Recharge (MAR): MAR is the process of pumping excess allocation waters into underlying aquifers for storage and future recovery. Although previously referred to as Aquifer Storage and Recovery (ASR), DEP prefers the term MAR as it covers multiple operational permutations that can go into these types of projects, one of which is ASR. MAR projects involve injected water first being treated to meet drinking water Maximum Contaminant Levels (MCLs) prior to being pumped underground, and revised review procedures were developed to meet Ground Water Quality Standards, N.J.A.C. 7:9C (GWQS). With the potential to provide water stored during off-peak periods to meet peak demands, combat drought conditions, and manage saltwater intrusion in Areas of Critical Water Supply Concern and Cape May County, DEP will continue to support the use of MAR where appropriate. The Division of Water Quality (DWQ) in coordination with the Division of Water Supply and Geoscience (DWSG) developed comprehensive review procedures for MAR projects to safeguard drinking water supply, maintain compliance with the Safe Drinking Water Act, and protect groundwater quality. DWQ is currently working to obtain information from existing MAR operations statewide to ensure consistent permitting for all MAR operations through the issuance of an individual NJPDES DGW permit.
- Water Source Substitution: A shift in water sources by a water supply system can reduce an existing stress in certain circumstances, like saltwater intrusion or contamination. However, water supply systems may face limitations in using this strategy due to cost and must ensure that substitutions don’t generate new problems.

POTENTIAL NEW AND EXPANDED SOURCES OF SUPPLY

As discussed throughout this Plan, some New Jersey water supply resources have confirmed or face the possibility of current or future stresses where water withdrawals may increase saltwater intrusion, stress

stream ecosystems, or simply exceed sustainable supplies, if they are not properly managed. DEP's Water Allocation program is responsible for ensuring water allocation permits protect water source integrity and water users. Past planning efforts have identified some capital projects as potential future water supply resources, for both source and finished waters. Along with the new or expanded projects, some of which are discussed below, it is critical that current assets are managed, maintained, exercised, repaired, etc. (which is discussed in detail in the WQAA and asset management topics throughout this Plan). Additionally, when new projects are built, long-term management plans and adequate financing must be included in operation and maintenance plans and budgets. The focus of this section is on the Northeast and Central Drought regions because of their large populations, older infrastructure, and previously identified projects. Additional details for other regions and general strategies are described in more detail in Appendix L.

- Northeast Drought Region: Within the Northeast Drought Region, P.L. 2005, c.349 appropriated $53 million dollars from the 1981 Water Supply Bond Fund, specifically, $30 million was appropriated for drought mitigation to enhance interbasin transfers, specifically the Virginia Street Interconnection/Pumping Station. However, 2017 regional stakeholder meetings between affected parties and DEP to determine the relevance of this project. The results of the stakeholder meeting, as well as additional DEP initiatives are outlined below:
    - Virginia Street Interconnection and Belleville Pumping Station: The Virginia Street Interconnection/Pumping Station, located in Newark, is limited in size and has limited resources devoted to operation and maintenance. The *2007 Interconnection Study* identified the Virginia Street Interconnection as a critical water supply asset with opportunity for inter-basin transfers between the City of Newark, New Jersey American Water (NJAW) – Raritan system, and the North Jersey District Water Supply Commission (NJDWSC). To reach its full design capacity, the NJAW-Raritan and Newark systems require improvements to transmission capabilities and a new pumping station is needed at the Belleville Reservoir site. DEP will work with purveyors to assess the utility of these improvements and will work with Central and Northeast drought region water suppliers to develop a strategy to make the Virginia Street Interconnection/Pumping Station fully functional and automated with the necessary enhancements.
    - Additional Water Infrastructure Options: The *2007 Interconnection Study* also found that additional enhancements to critical water supply infrastructure in the Passaic and Hackensack basin would greatly increase the region's ability to address water supply emergencies such as infrastructure repair and drought. Examples of additional enhancements include: (a) the preservation of the full operational capacity of Newark's Cedar Grove Reservoir in a manner that meets EPA and DEP's uncovered finished water reservoir safe drinking water requirements, and (b) the expansion of the Chittenden Road interconnection to include the North Jersey District.
    - Coordinated Operations: Modeling and assessment conducted by DEP show that the coordinated operation of the larger surface water supply systems in the northeast and central regions can greatly increase resilience and decrease the frequency of system stress. One primary example of this is the use of the Wanaque Aqueduct which transfers

water from NJDWSC sources to the Oradell Reservoir operated by Veolia. Modeling conducted by DEP and both utilities showed that coordinating operations and delaying water transfers reduced simulated drought days over the period-of-record and increased overall safe yield of the two systems. Recent events suggest that real-world benefits were achieved. The potential exists for other shared and coordinated operations to increase resilience, but additional modeling, new finished water interconnection and infrastructure, and cost sharing agreements would need to be designed and implemented.

  - Uncovered Finished Water Reservoirs: In 2006, the Federal Safe Drinking Water Act regulations required existing open finished storage reservoirs to be covered to prevent contamination or to provide for 4-log virus removal, 3-log Giardia inactivation, and 2-log Cryptosporidium inactivation treatment by April 1, 2009. There are only 20 uncovered finished water reservoirs (UFWR) still in use in the United States, 5 of which are in the State of New Jersey, with the major ones located in northeastern New Jersey. While they represent critical sources of finished water supply (often close in proximity to demands), they also pose unique water quality risks. For example, PVWC's New Street Reservoir was inundated by untreated runoff from the remnants of Hurricane Ida in 2021 requiring a multi-week boil-water advisory. DEP will continue to actively work to reduce risks posed from these sources and ensure that all drinking water quality standards are met while preserving critical finished water supplies. These actions apply to UFWR throughout the state such as the one utilized by Trenton Water Works.
- Central Drought Region: The Eastern Raritan Basin Water Feasibility Study, the 1996 Plan, and the 2017 Plan identified several projects in the Raritan River Basin that can be used to increase the safe yield of the New Jersey Water Supply Authority (NJWSA) within the Raritan Basin and the Central Drought Region.
  - Kingston Quarry Reservoir: One project under consideration is the Kingston Quarry Reservoir. It was initially proposed by Trap Rock Industries as a reclamation plan for their rock quarry once operations cease. It is envisioned as two large water storage pool areas located at an elevation below the Canal that would store unused Delaware and Raritan Canal flow and/or high flows from the Millstone River for eventual release back into the canal during low-flow periods. This project is considered a viable strategy only if legal issues related to the operation, land, and necessary storage volumes are met at the required time of transference. As of 2023, this operation quarry is still being actively used, DEP and NJWSA will consider engaging a consultant to research next steps to pursue the Kingston Quarry Reservoir project.
  - Confluence Pumping Station: Confluence Pumping Station is a second project for the Central Drought Region that can provide additional safe yield of approximately 50 million gallons per day (mgd)in the NJWSA Raritan System. This project would entail replacing an existing release pipeline from Round Valley Reservoir to the South Branch of the Rockaway Creek that is currently used for releases from Round Valley. The new pumping station would construct a new pipeline from this existing discharge point on the Rockaway Creek to the confluence of the North and South branches of the Raritan and

pumping station (in the pool formed by the Headgate dam) would supply water from downstream to the reservoir. Although this project is currently not being actively pursued, it is assumed to be one of several priority projects if additional safe yield is needed. Recent announcements by the DEP's Office of Natural Resource Restoration outlining plans to remove the Headgate dam complicate the development of the project if it is needed in the future.

  - **Additional Opportunities**: Additional opportunities for the Central Drought Region include: (a) the application of a multi-day average passing flow scheme to meet the requirements of New Jersey Statute NJSA 58:1B-1 et seq., and (b) bolstering the interconnection of water supply systems between the Central (Raritan River Basin) and Coastal North Drought Regional systems. The use of a multi-day averaged passing flow scheme would also allow the New Jersey Water Supply Authority to reduce over releases since there would be additional time to balance out under releases over the next several days.

- **Finished water-supply interconnections:** Multiple reports, modeling exercises and staff experiences have shown that maintenance, use and expansion of finished water-supply interconnections are critical to address water supply emergencies, both short-term (i.e. water main breaks) or long-term (i.e. drought, loss of source, or water quality treatment limitation). This recommendation applies throughout the state to both small and large water systems.
- **Retention of Previously Acquired Water Supply Properties**: Although they are not presently figured in near-term capital water supply development, DEP will ensure the Six Mile Run Reservoir and Hackettstown Reservoir as well as other identified properties remain preserved for future water supply purposes.
- **Advanced Treatment Technologies**: Advanced treatment technologies may also be used to develop new sources of water supply. Implementation of RWBR can be used as a water supply source for existing and new non-potable purposes. DEP will assess and consider proven treatment technologies to convert "non-potable" water supply sources to "potable sources."

As issues emerge and water supply conditions evolve, specific priority projects may change. Future Plans and plan updates will document any new projects.

ADEQUATE ASSET MANAGEMENT

Increasing water supply resilience requires adequate asset management of water supply systems and infrastructure. This includes estimating infrastructure needs, maintaining infrastructure, and a determination of how infrastructure will be financed. DEP offers several programs to assist in these efforts, including its rules and guidance provided in its Asset Management Policy program and Capacity Development program. Each of these aspects of asset management and DEP's existing programs to assist in these efforts is discussed below, with greater detail provided in Appendix L.

- **Water Quality Accountability Act:** The Water Quality Accountability Act (WQAA), P.L. 2017, c. 133 (WQAA), enacted on July 21, 2017, established new requirements for purveyors at certain PCWS to improve the safety, reliability, and administrative oversight of water infrastructure. The WQAA

became effective on October 19, 2017. Additionally, on November 8, 2021, amendments to the WQAA were signed into law as P.L. 2021, c. 262. These changes enhance the cybersecurity requirements of the WQAA, among others. The Act applies to PCWS with more than 500 service connections (approximately 1000-1500 residents, for PCWS that primarily serve residential customers); approximately 300 water systems in New Jersey are regulated under the WQAA. Further information on the program is available from DWSG WQAA.

The WQAA requires purveyors to create and implement an asset management plan designed to inspect, maintain, repair, and renew its infrastructure consistent with standards established by the American Water Works Association. Asset management plans must be developed and must include annual identification of critical infrastructure repair and restoration or replacement projects for the next three years. Submittal of the asset management plans to DEP is not required by the WQAA, but the plans must be available for DEP review when requested. Purveyors must annually submit a Capital Improvement Report, which must outline their capital projects completed pursuant to their asset management plans, and identify projects planned up to 10 years in the future. Over time this allows for a comparison of anticipated versus actual expenditures, water system performance, and other technical, managerial, and financial capacity indicators. In addition, the Act also specifies a frequency for routinely testing valves and fire hydrants, compliance aspects of drinking water regulations, and cybersecurity programs.

It should be noted that the WQAA only applies to public water systems and has no obligations for wastewater utilities. While there are different regulatory and management obligations between the different utilities, service disruptions and environmental impacts caused by aging and deteriorating infrastructure have major societal impacts. Additionally, many purveyors subject to the WQAA also own and operate wastewater utilities. This has created some confusion and uncertainty as different sides of a water utility’s “shop” may have unequal regulatory obligations. Additionally, there are a handful of cases where large, regional water suppliers may pump and treat water on a wholesale basis to other utilities which may have to comply with the WQAA, but do not have enough direct individual customers to be subject to the WQAA themselves.

- **Estimating Infrastructure Needs**: Several existing reports have evaluated New Jersey's drinking water systems infrastructure and estimated the potential cost of addressing its infrastructure needs. In its "2021 Report Card," The American Society of Civil Engineers New Jersey Chapter gave New Jersey a "C-" (mediocre) grade for its drinking water infrastructure (see New Jersey Infrastructure Report Card and New Jersey Infrastructure Report Card Summary) and identified over $8.6 billion in total drinking water need. Moreover, the USEPA's 7th Drinking Water Infrastructure Needs Inventory released in April 2023 estimated that $12.2 billion in capital investments will be needed over the next 20 years to update, install, and replace New Jersey's drinking water infrastructure (See EPA 7th Drinking Water Infrastructure Needs Survey and Assessment).

(*Top*) Hamden Pump Station operated by the New Jersey Water Supply Authority in Clinton Township, New Jersey; (*Bottom*) Infrastructure located in Veolia's Haworth Water Treatment Plant in Haworth, New Jersey.

- **DEP Asset Management Policy Program**: DEP promotes responsible asset management and adequate infrastructure reinvestment, which are essential to ensuring long-term integrity of water system assets and the sustainable supply of safe drinking water to customers. DEP encourages asset management through both rules and ensuring permit requirements. Guidance documents are also available to assist with clarifying permit requirements and to ensure best management practices for governing water system maintenance, operation, and management. Detailed information about asset management can be found at DEP's Asset Management webpage: DEP Asset Management.

- **Maintaining Infrastructure**: Starting in 2008, the New Jersey Clean Water Council (CWC) has conducted public hearings focused on water-related environmental infrastructure (including drinking water), regarding objectives, needs, financing, and management in the State. The need for greater attention on asset management was identified as a recurring theme at these hearings, including adequately funding related assets on a sustainable basis. Based on the recommendations developed from these hearings, DEP developed asset management guidance focused on: (a) a routine asset condition assessment; (b) a programmed and preventive maintenance system; and (c) a procedure to evaluate life-cycle cost impacts of repair or replacement decisions.
- **Securing Infrastructure and Critical Assets**: Ensuring that water supplies and their associated infrastructure are physically secure (in addition to cyber secure) is a key element in providing New Jerseyans with safe and adequate supplies. The distributed nature of water supply sources (both wells and reservoirs), treatment plants, and distribution networks creates unique risks for the DEP, water utilities, and local governments, and the residents they serve. For example, some of the state's largest reservoirs, such as Spruce Run, Round Valley, and Monksville, allow recreation and include private property on the shoreline. While this situation creates unique recreational opportunities, it also creates additional security risks. Another example is aqueducts, canals and large pipelines that run long distances from water sources to demand centers which require additional resources to monitor. Many of these have been in existence for almost a century and the public and local governments often overlook their significance. In light of these risks, the DEP will continue to require and expand, where necessary, the physical security requirements defined in N.J.A.C 7:19 2.14 and N.J.A.C 7:10-11.6.
- **DEP Capacity Development Program to Identify Problem Systems:** DEP administers the Capacity Development (CapDev) program to try to identify and quantify individual system problems related to potential infrastructure needs and financial shortfalls in developing and maintaining infrastructure. Originally a mandate of the 1996 Federal Safe Drinking Water Act (SDWA) amendments, it is a tool to identify specific water systems with technical, managerial, and financial (TMF) deficits and provide the tools needed to overcome their shortcomings and attain long-term system viability. Every three years the CapDev program identifies a list of non-compliant water systems that require assistance to resolve TMF issues based on input from DEP's Compliance and Enforcement section and county health departments. More information on this program is available at: DWSG Capacity Development Program.
- **Infrastructure Financing**: Providing safe drinking water requires heavy capital investment, and the costs of building environmental infrastructure are often placed on ratepayers and taxpayers. In partnership with the New Jersey Infrastructure Bank (I-Bank), DEP promotes the use of the New Jersey Water Bank, which implements the Clean Water and Drinking Water State Revolving Funds (SRFs). The NJ Water Bank provides low-interest financing for Technical Assistance and Capital Improvement projects to keep costs to the public as low as possible. The I-Bank was originally created by legislation enacted in 1986 to establish an independent State authority to manage efficient and low-cost financing for environmental infrastructure projects. In addition to administering the SRFs, the NJ Water Bank has recently been able to enhance its funding capacity

due to the enactment of the Bipartisan Infrastructure Law (BIL). Due to this influx of funding, DEP also initiated the Water Infrastructure Investment Plan (WIIP), which highlights available low-cost funding to eligible borrowers, defray maintenance costs, and improve New Jersey's water infrastructure for its ratepayers. DEP's Bureau of Water System Engineering also jointly manages the Drinking Water State Resolving Fund (DWSRF) with the DEP's Municipal Finance and Construction Element and the New Jersey I-Bank.

ENVIRONMENTAL JUSTICE AND WATER SUPPLY

Robert Bullard suggests that "Environmental justice embraces the principle that all people and communities have a right to equal protection and equal enforcement of environmental laws and regulations." (Bullard, 2023). Many current regulatory frameworks fail to fully meet this expectation; extensive research shows that land uses causing environmental harm are strongly associated with overburdened communities. The USEPA states that "[e]nvironmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies," (EPA, 2023). This definition combines results and procedural approach. The New Jersey Environmental Justice Law (N.J.S.A. 13:1D-157) does not define environmental justice, per se, but rather includes a statement of purpose: "The Legislature further finds and declares that no community should bear a disproportionate share of the adverse environmental and public health consequences that accompany the State's economic growth…".

In accordance with the Environmental Justice Law, DEP has mapped the extent of overburdened communities (OBCs), defined by the criteria below, as census block groups with:

1. at least 35 percent low-income households; or
2. at least 40 percent of the residents identify as minority or as members of a State recognized tribal community; or
3. at least 40 percent of the households have limited English proficiency.

The total population of OBCs mapped by DEP is nearly 4.8 million, more than half of the state's population. (See: What are Overburdened Communities?). These areas are shown in the EJMAP (Where Are New Jersey's Environmental Justice Communities?).

While environmental justice addresses essentially all aspects of environmental policy, the focus here is on implications regarding water supply and the relationships between affordability, asset management and resilience. This Plan takes the first steps to identify these relationships and outlines the major areas where additional research and action is needed.

OVERBURDENED COMMUNITIES AND PUBLIC WATER SYSTEMS

Using the mapping of OBCs, PCWS service areas, and recent research on the affordability of drinking water and wastewater utilities (Van Abs et al., 2021), it is possible to identify PCWSs that are entirely or largely within OBCs, their service area populations, the percentage and population of households that

may face water and sewer utility costs that pose affordability concerns (using a combination of utility costs and household incomes), and whether the PCWSs face water supply constraints that may compromise existing or future supply of water to customers. Of the 584 PCWSs analyzed, 24 PCWSs with total populations of more than 1.3 million have at least 70 percent of their service area in OBCs. Of this population, roughly 300,000 people are in households that may face affordability concerns, ranging from 11 to 43 percent of the households served in each system.

Not all OBCs are the same. Many PCWSs with a high percentage of OBCs serve historic urban centers and were built during times of relative wealth, mostly as major industrial centers (e.g., Camden, Jersey City, Newark), but in the post-World War II period saw a major reduction in wealth.[1] Several of these urban PCWSs face projected reductions in water demands from 2020 to 2050, which will reduce revenue and therefore increase the costs per gallon of system operation, maintenance and asset management for the system's customers. In other cases, significant growth is anticipated, which will provide additional revenue but may also stress the PCWS's ability to meet water demands. In addition to historic urban centers there are newer PCWSs, serving major post-war suburban areas that also face similar issues.

Table 5.2 provides a summary of PCWS with high percentages of OBCs. Figure 5.15 shows one general and four specific maps and summary data showing the relationship between selected PCWSs and OBCs.

Table 5.2 PCWS with High Percentages of Overburdened Communities

PWSID	PCWS Name	% Over-burdened Community	Estimated 2018 PCWS service area population	Estimated % HH* below affordability baseline threshold	Estimated Population of HH* below affordability baseline threshold	Projections
NJ0705001	East Orange Water Commission	100%	64,404	27.7%	17,865	Demand declining
NJ1216001	Perth Amboy Dept of Municipal Utilities	100%	51,854	32.6%	16,887	Demand stable or declining
NJ0408001	Camden City Water Department	100%	44,726	60.7%	27,152	Demand declining
NJ0102001	Atlantic City MUA	100%	38,260	49.6%	18,983	Demand declining
NJ0717001	Orange Water Department	100%	30,405	32.1%	9,748	Demand declining
NJ0338001	Willingboro MUA	100%	33,086	13.8%	4,580	Demand stable, supply sufficient
NJ0714001	Newark Water Department	99%	279,082	34.8%	97,138	Growth expected, demand declining
NJ1111001	Trenton Water Works	99%**	217,000	26.0%	56,420	Demand declining, supply available
NJ2004001	Liberty Water Company c/o NJ American	98%	128,124	31.4%	40,294	Demand growth, supply available

[1] Newark is a good example of this pattern. In the late 1800s, Newark was wealthy enough to purchase 35,000 acres of land in rural areas of Morris and Passaic counties and build five reservoirs for its Pequannock Watershed system, providing high-quality source water. After peaking at nearly 450,000 residents, Newark's population declined to less than 275,000. Newark has nearly one-third of its households with incomes below the federal poverty line. Only in recent years has Newark's population begun to increase, to roughly 300,000 in 2023.

PWSID	PCWS Name	% Over-burdened Community	Estimated 2018 PCWS service area population	Estimated % HH* below affordability baseline threshold	Estimated Population of HH* below affordability baseline threshold	Projections
NJ0701001	Belleville Township Water Department	98%	33,005	11.0%	3,619	Demand stable, supply constrained
NJ1215001	North Brunswick Water Department	97%	41,922	15.2%	6,379	Demand stable, supply sufficient
NJ1221004	South Brunswick Township	96%	43,835	11.4%	4,991	Major growth, supply available
NJ1214001	New Brunswick Water Department	94%	56,012	43.3%	24,269	Demand declining
NJ1808001	Franklin Township (Somerset County)	93%	62,261	18.7%	11,618	Demand growth, supply sufficient
NJ0906001	Jersey City MUA	92%	261,687	24.7%	64,735	Major growth, peak supply constrained?
NJ0901001	Bayonne City Water Department	89%	65,325	24.4%	15,911	Demand growth, supply sufficient
NJ0614003	Vineland City Water and Sewer Utility	88%	51,488	22.4%	11,555	Demand growth, supply constrained?
NJ1409001	Dover Water Commission	86%	26,319	23.9%	6,301	Demand declining
NJ2013001	Veolia (Rahway)	82%	29,380	22.1%	6,501	Demand declining
NJ1205001	Edison Water Company	82%	44,156	12.5%	5,533	Demand stable, supply sufficient
NJ1225001	Middlesex Water Company	80%	203,772	16.1%	32,833	Demand declining
NJ1605002	Passaic Valley Water Commission	79%	306,902	31.0%	95,130	Demand declining
NJ0424001	Merchantville Pennsauken Water Commission	76%	44,192	21.1%	9,338	Demand stable to declining
NJ0702001	Bloomfield Water Department	74%	48,890	11.8%	5,757	Demand declining
NJ1219001	Sayreville Borough Water Department	70%	44,251	17.1%	7,557	Demand growth, sufficient supply

*HH means households

**The 99% value for Trenton Water Works' percent OBC was calculated based on the city's municipal boundary although the system also provides water to communities outside of the boundary.

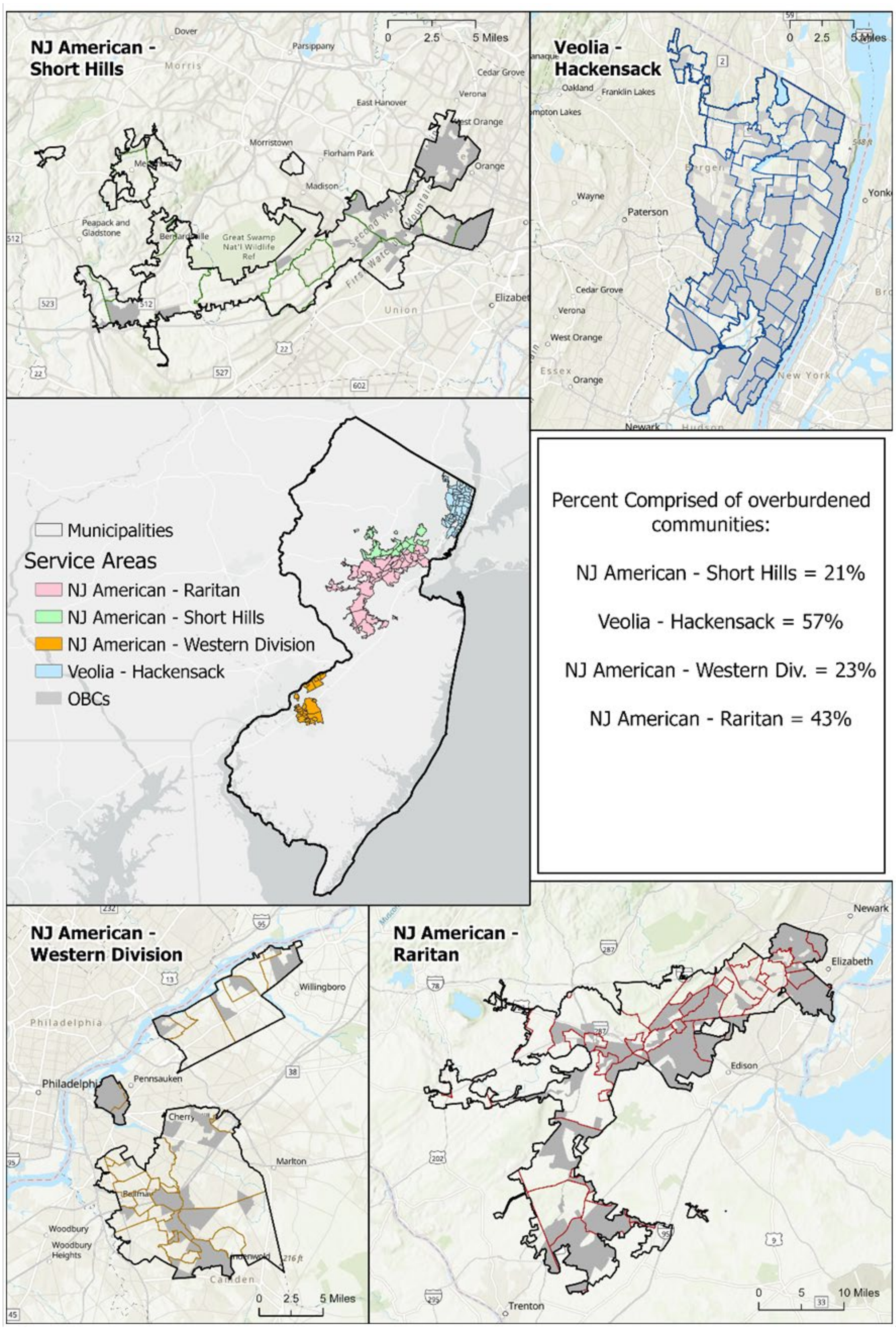


Figure 5.15 Maps and summary data showing relationship between selected PCWSs and OBCs.

Ensuring that all residents are able to afford perhaps their most essential utility, water, remains a challenge for the PCWSs that serve low-income communities. PCWSs must ensure there is adequate revenue to support needed investment to maintain reliable, safe water service throughout their entire service area, but some low-income residents may face challenges in being able to continue to afford their water bill as rates are expected to increase in the future. This challenge became much more apparent during the COVID-19 pandemic, when many residents in New Jersey fell into arrearages as a consequence of non-payment for their water bills. For investor-owned water utilities alone, BPU identified approximately 142,000 residential customers who were in arrearages for their water bills in May 2022, representing approximately $42 million in unpaid bills (BPU May 2022 Arrearages for Posting). Shutoffs were suspended for the duration of the pandemic, allowing customers the flexibility to defer paying water bills to pay for other essential costs. However, the experience did illustrate how many residents are economically vulnerable and face the possibility of being unable to pay for their water bills. This scenario creates a ripple effect where the PCWS which serves the community may not generate sufficient revenue, resulting in said utility being unable to initiate necessary capital improvements, or even fund routine maintenance work, to maintain reliable water service. This problem was temporarily addressed in New Jersey via the Low-Income Household Water Assistance Program (LIHWAP), administered by NJDCA, which used federal dollars to help cover that resource gap, particularly for residents who were hardest hit by the COVID-19 pandemic. However, the federal funds supporting LIHWAP have since been exhausted, meaning that LIHWAP is not currently able to deploy additional resources to support New Jersey's neediest residents. Given the reliance on LIHWAP support to offset water utility costs, it is recommended that similar initiatives are evaluated and implemented.

The importance of interconnections between water systems to promote resilience is well attested to in this Plan. Systems that lack these connections have fewer options in responding to loss of supply, which could occur for a variety of reasons, and face greater risk of failing to provide adequate quantities of water with the necessary quality to customers. Where water systems serve OBCs, these risks may be compounded. Table 5.3 summarizes systems lacking interconnections where OBCs comprise the majority, by land area, of the service area, suggesting the potential for increased difficulties in financing future investment into water system redundancy. Systems that serve smaller populations will have fewer customers to fund system improvements and may need access to financial assistance programs. One example is the presence of PFAS contamination anticipated to be found throughout the state and New Jersey's (and potentially the lower EPA) MCL criteria necessitating the installation of additional and costly treatment requirements.

Water systems were categorized and counted based on the classes defined in NJSDWA Rule 7:10-15.4. Systems without interconnections are defined here as those that did not record a water transfer or interconnection between 2011 and 2020. This is a preliminary analysis which could lead to a more specific study of communities that may or may not face water supply-related risks.

Table 5.3 Non-interconnected water systems where the majority of service area is comprised of OBCs.

PCWS	Class 1 (Pop. 25 to 999)	Class 2 (Pop. 1,000 to 9,999)	Class 1 (Pop. 10,000 to 49,999)	Class 1 (Pop. 50,000 or more)
System Counts	27	13	1	0

OVERBURDENED COMMUNITIES AND PRIVATE WELLS

There are also numerous overburdened communities outside of PCWS service areas; these communities rely on private wells for household and business water supplies. Figure 5.16 shows OBCs outside of PCWS service areas and includes HUC11s with potential water availability limitations. Where private wells suffer from contamination or loss of supply due to groundwater declines, the stresses on the OBCs will be exacerbated. Stresses from contamination may be felt more acutely in some ways by lower income, lower density, and more rural OBCs served predominantly by private wells. As lower income private well owners may not have the financial resources, or education to fully appreciate the importance of system maintenance and regular testing for not only contaminants with acute health effects (E. Coli or Nitrate), but also chronic (e.g. Arsenic) or emerging contaminants (e.g. PFAS or 1,4-dioxane), these individuals may be more susceptible to exposure to these health effects via their drinking water. Even if an individual in an OBC is able to obtain the financial resources to conduct such a test, they may struggle further to either install treatment for the contaminant(s) of concern, connect to a municipal water supply, or else switch to bottled water. These options are costly, and limited resources outside of New Jersey's Spill Fund are available. Additionally, the fundamental challenge of owning and adequately maintaining an aging drinking water well remains costly. Lower income residents may lack the financial capital to pay the cost for a licensed well driller to replace a failing drinking water well, and needy residents may resort to hiring unqualified, or unlicensed individuals to meet their potable water needs. DEP's Technical Assistance Funding program may be able to assist in some instances. More information is available at the DEP WIIP Technical Assistance Request website.

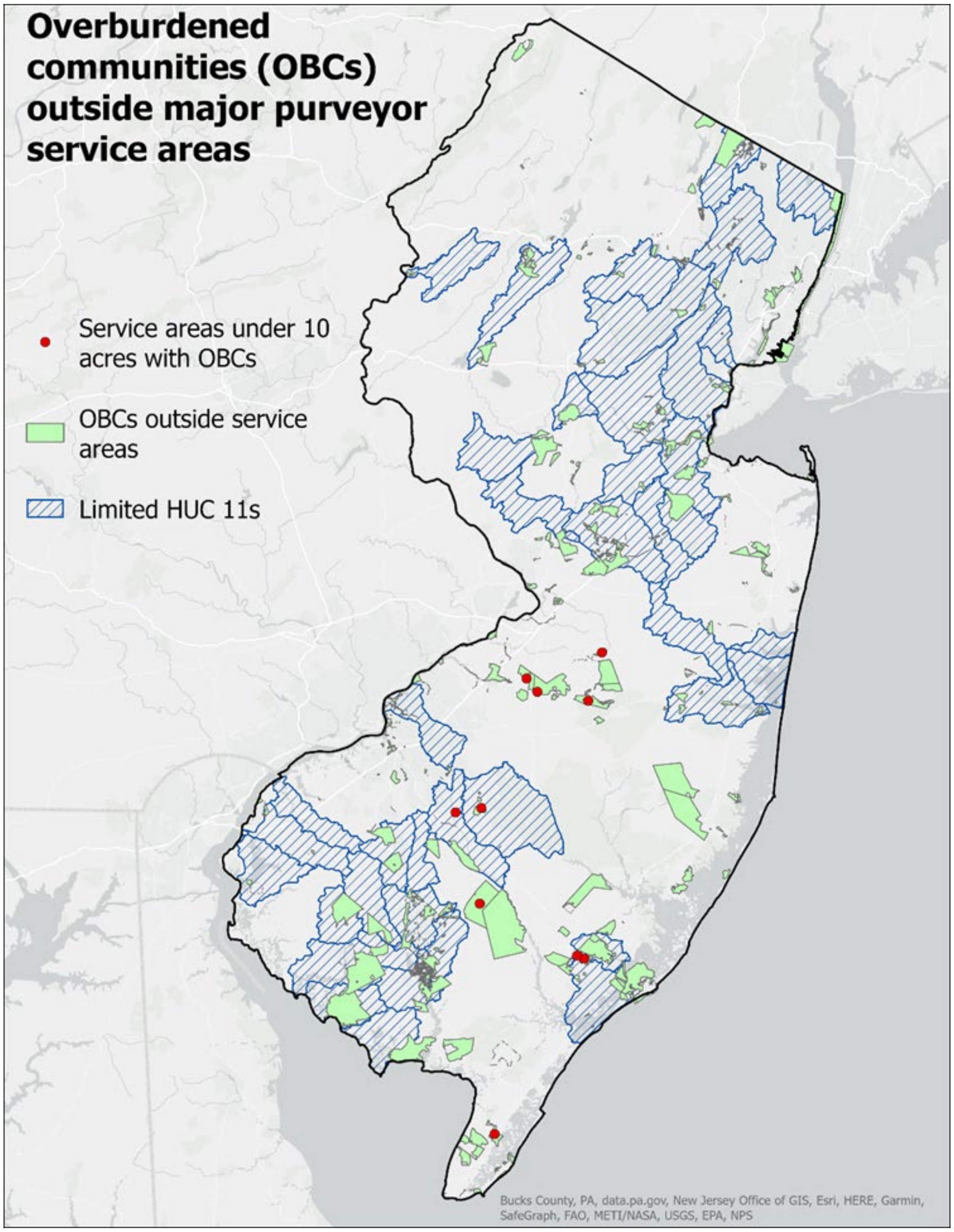


Figure 5.16 Overburdened communities outside of PCWS service areas and HUCs with potential unconfined aquifer availability limitations.

ENVIRONMENTAL JUSTICE RECOMMENDATIONS

- DEP should support legislative efforts to explore the establishment of a permanent LIHWAP program across New Jersey. Additional efforts could be made at the federal level. By providing support for low-income residents to consistently be able to afford water bills, this can avert the need for water shutoffs as well as provide the buffer needed for PCWSs to establish the rates necessary to fully fund the needs of their water infrastructure. This would also ensure that even low-income customers are able to afford water service as rates increase in the future. The legislature should consult with the NJDCA and BPU to identify possible parameters of a

permanent LIHWAP, and lessons learned from implementing the temporary program to ensure that eligible homeowners would be aware of the program, that PCWSs would be supportive and accepting of these funds, and that the program would be sustainable to support residents' needs.
- The DEP should consider working with the New Jersey Department of Health (NJDOH), NJDCA and local and county health to sponsor additional research into the scope of financial need for low-income private well owners.
- While any resident served by a private well is subject to the health risks associated with a contaminated, or failing well, these concerns are exacerbated within OBCs due to the historic challenges experienced by these communities. To alleviate the financial burdens which may accompany the ownership of a private well or small PCWS (such as mobile home parks or similar types of isolated systems), DEP should support legislative efforts to explore the establishment of a revolving funding source that provides low- or no-interest loans or grants to eligible homeowners to ensure support is accessible to residents in need for the replacement of failing drinking water wells due to age, or installation of treatment for naturally occurring contaminants (or human-made where a responsible party is not apparent). This fund could be operated in a revolving fashion and modeled after the highly successful State Revolving Funds for both Drinking Water and Clean Water.

PROTECTING DRINKING WATER

DEP implements the New Jersey Safe Drinking Water Act (NJSDWA) and has been granted primacy for implementing the federal Safe Drinking Water Act by the USEPA. Most provisions of these laws are focused on ensuring the treatment and delivery of drinking water that meets federal and state standards to customers of public water systems. Ensuring safe drinking water, however, does not rely solely on treatment. Rather, it uses a multi-barrier approach that starts with protection of the water source, as a treatment system will be more successful if the incoming source waters are of high quality. Poor quality source waters increase the treatment technology needed, the cost of treatment, and the potential for treatment difficulties. It is for this reason that the SWAP was developed and integrated with ongoing regulatory programs that protect water sources. The following sub-sections discuss DEP efforts to ensure safe drinking water through the implementation of the Safe Drinking Water Program including the Lead and Copper Rule, and the Water Quality Accountability Act.

SAFE DRINKING WATER PROGRAM

DEP's Division of Water Supply and Geosciences is responsible for regulating and guiding the proper operation of public water suppliers in New Jersey, in compliance with the NJSDWA (N.J.S.A. 58:11 et seq. and N.J.S.A. 58:12A-1 et seq.) and the NJSDWA Rules (N.J.A.C. 7:10). The suppliers are responsible for treated or delivered drinking water quality, system operations, finished drinking water storage, water pressure, etc., and submitting regular compliance reports to the DEP. Many of these reports, including information on the system's licensed operators, reported water quality sampling, ~~permit~~ water system violations, and other relevant data, are available to the public at the New Jersey Drinking Water Watch

web page: Drinking Water Watch. Although customers are directly notified of any violations in applicable public notices and their annual consumer confidence reports, Drinking Water Watch increases the accessibility of this data to the public. DEP also collaborates with the NJDOH and local health boards on implementation of the Private Well Testing Act (N.J.S.A. 58:12A-26) and Private Well Testing Act Rules (N.J.A.C. 7:9E), which require testing of private wells upon sale or transfer of residential property.

DEP is responsible for working with drinking water utilities in the event of water contamination issues, including water main breaks and water pressure problems that might require drinking water advisories and the response to acute public health threats (e.g., E. Coli), to achieve compliance with all regulatory requirements as quickly as possible. One of the best ways of ensuring compliance is to prevent problems from developing in the first place; DEP operates a Capacity Development Program by promoting effective technical, managerial, and financial capacity for all water utilities, through technical assistance and training and funding (see DEP-DWS&G Capacity Development Program). DEP also conducts research to identify potential drinking water issues and develop new or revised Maximum Contaminant Levels (MCLs) or treatment techniques for drinking water contaminants.

SAFE DRINKING WATER PROGRAM NEXT STEPS

As mentioned above, under N.J.A.C. 7:10, a permit is required to be obtained from DEP by PCWS (and PNCWS that serve Federal or State facilities) for the construction or modification of drinking water infrastructure and treatment. While permits are issued for new or modified components or processes, there is no permit or approval issued by DEP for the overall operation of a water system regulating its management and maintenance.

Some water systems take a proactive approach to ensuring their system is properly managed and maintained. These systems may take a variety of measures such as:

- the development of Operation & Maintenance manuals that are routinely referenced and adhered to by personnel employed by the water system;
- ensuring sufficient staffing, including the appropriate licensed individuals;
- taking extra steps not required by regulation or permitting requirements, such as routinely inspecting and maintaining assets (e.g. water storage tanks); and
- maintaining accurate records of operations, maintenance activities and system disruptions.

However, not all systems are proactive and it’s possible that a water system may comply with delivering water that meets drinking water standards at key regulatory compliance points (e.g., at the point of entry to the water system) but deliver water that degrades prior to reaching the customer’s tap due to poor maintenance or management of the water system overall. Other water systems may struggle to meet drinking water standards due to the lack of robust operational and maintenance standards.

Therefore, DEP has started to explore the feasibility of the issuance of Water System Operation Permits to specify conditions of proper water system management and maintenance. Other states including Alabama, California, Iowa, South Carolina, Vermont and Virginia currently issue these types of permits to their regulated community. The conditions that could be included in these types of permits would result in higher quality water to customers and result in fewer violations of drinking water standards. DEP seeks

to enhance its existing authority to issue such permits. DEP will assess, with stakeholder input, whether these types of permits should be issued and if so, whether conditions should be standard for each system, or if conditions should vary based on system size and type or other factors.

Roughly ten percent of New Jerseyans rely on private wells (about 400,000 homes) and as such the homeowners are the primary agent responsible for ensuring adequate water quality (See New Jersey Private Well Information). Many homeowners rely on private companies to test and treat their water and DEP is exploring the possibility of certification and licensing requirements for installers of treatment systems within the home. New Jersey homeowners that self-supply potable water via a private domestic well or who are publicly served but desire secondary treatment may opt to install point-of-entry (POE) or point-of-use (POU) treatment devices in their home. Currently, there are no certification or licensing requirements for individuals who install POE or POU treatment devices in homes in New Jersey. Although there are reputable and experienced companies within the state, there are some which lack the knowledge and expertise to provide the correct treatment units that effectively and safely reduce contaminants of concern. Due to this lack of professional certification or licensing, a potential gap exists which could result in residents receiving ineffective, or in some cases, actively detrimental treatment systems which could introduce new health risks to homeowners and their families. A statewide certification program for residential POE or POU systems would ensure quality of service and provide confidence for New Jersey residents that the treatment they pay for is effective in providing the advertised goals and is properly installed to not cause further harm. Such a certification program would need to be designed to align with relevant requirements for licensed plumbers. As an analogue, there is an existing radon treatment professional certification program in New Jersey that can serve as a model for the proposed certification. The radon program originated within DEP in the 1980s, but became mandatory in 1991, and now maintains certifications for about 900 individuals and 35 businesses.

LEAD AND COPPER RULE

Lead is a pollutant that is rarely found in source water withdrawn from the streams, reservoirs, and aquifers of New Jersey. It is commonly found when treated drinking water chemically reacts with the lead pipes and plumbing fixtures when moving from a water treatment plant to the end user, most often in the service lines between the water mains and a customer meter. DEP's Lead Team has worked with a wide variety of industry and other stakeholders to ensure that the Federal Lead & Copper Rule (LCR) requirements are fully being implemented in New Jersey and to create guidance to support the New Jersey Board of Education rules that require sampling for lead in water in New Jersey schools. As a result, the State Legislature adopted and the Governor signed legislation in 2021 requiring that all PCWS replace all lead service lines within 10 years. This legislation predated but will support the implementation of federal LCR requirements for lead service line replacements. The New Jersey safe drinking water requirements for lead will be updated as necessary in response to federal LCR requirements as they change. More information is at Lead in Drinking Water.

RESILIENCE, SUSTAINABILITY, AND CLIMATE CHANGE

As discussed in Chapter 4, current trends in water availability modeling indicate that surface water safe yields face limited changes through the year 2050 and surficial aquifers in many but not all HUC11 areas may see increased water availability. Indoor residential water demands are likely to continue to decline, a long-standing trend that will not be affected by climate change. However, outdoor water demands are likely to continue to increase, as temperatures increase and the growing season lengthens, and periodic dry spells become more frequent. Flood events are likely to become more frequent and severe as annual precipitation increases and storms become more intense. Finally, sea level rise will put more developed lands and some coastal plain wells at risk.

Beach erosion control structure near East Point in Cape May County.

These findings are important to environmental justice. As discussed earlier in this chapter, PCWS resilience is dependent upon the ability to respond and adapt to environmental forces. Sustainability of a PCWS depends heavily upon the ability to charge rates that reflect the true cost of water supply, so that the PCWS assets are well maintained. Any PCWS with a high proportion of lower-income households will have difficulties raising rates to pay for good asset management in normal times. When disasters strike, a PCWS could both lose revenue and face disaster related disruptions and response costs, not all of which will necessarily be eligible for reimbursement by state and federal disaster recovery funds.

Sea level rise could result in the loss of service area, through a forced move of customers and demolition of development that cannot be protected cost-effectively. While many areas along the Jersey Shore coast have high-value developments, there are areas along the shores of the Arthur Kill, Newark Bay, Hackensack Meadowlands, Hudson River, Raritan Bay, Delaware Bay, and tidal Delaware River that have concentrations of low-income households. These areas face greater difficulties in attracting funds for risk-reduction projects that protect development. This is especially true for federal funds that require project benefits that exceed costs, a difficult test when development values are low. The loss of service area will result in lower revenues along with the need to address abandoned infrastructure. Conversely, there may be some situations where rebuilding elements of the water supply infrastructure, while doable and where funds may be available, simply does not make sense in the larger context of community sustainability and long-term climate change impacts. With the support from New Jersey's Interagency Council on Climate

Resilience, DEP released the New Jersey Climate Change Resilience Strategy (NJDEP, 2021) and continues to expand guidance which can be found at the DEP Climate Change website to help governments, utilities, and communities make informed decisions.

Finally, many PCWS in New Jersey will face additional costs for treatment of recent and upcoming MCLs for toxic and carcinogenic substances such as PFAS chemicals, 1,4 dioxane and others, along with the costs of removing lead service lines as required by state law. Therefore, the long-term ability of PCWS to sustain operations and to respond to external disasters is lower when their customer base faces high affordability stresses. There is no permanent state or national program to assist customers so that PCWS can set rates at viable levels without harming their customers.

STATEWIDE SAFE DRINKING WATER ASSESSMENT

To comply with the NJSDWA, public water suppliers apply a variety of treatments prior to finished water reaching customers. The figures and tables below serve as a high-level assessment of these processes, displayed in both statewide summary form and mapped to provide geographic context. While emerging contaminants are a concern, and are addressed in detail in Chapter 2, this section serves to communicate some of the many actions that are currently taken to ensure residents of New Jersey have access to continuous supplies of safe drinking water. The analysis underlines how water from different sources and geographic areas must be treated differently. A complete understanding of the current steps undertaken to provide the residents of the state with safe drinking water is useful in planning for future water supply needs. For the following tables and figures note that some water systems rely on wells that are so close to surface water sources that they are considered groundwater under direct influence (GUDI). These wells were categorized as groundwater for the purposes of this assessment. The number of active water systems and the treatment processes they apply are subject to change. The data used to generate the figures and tables below was generated in March 2023.

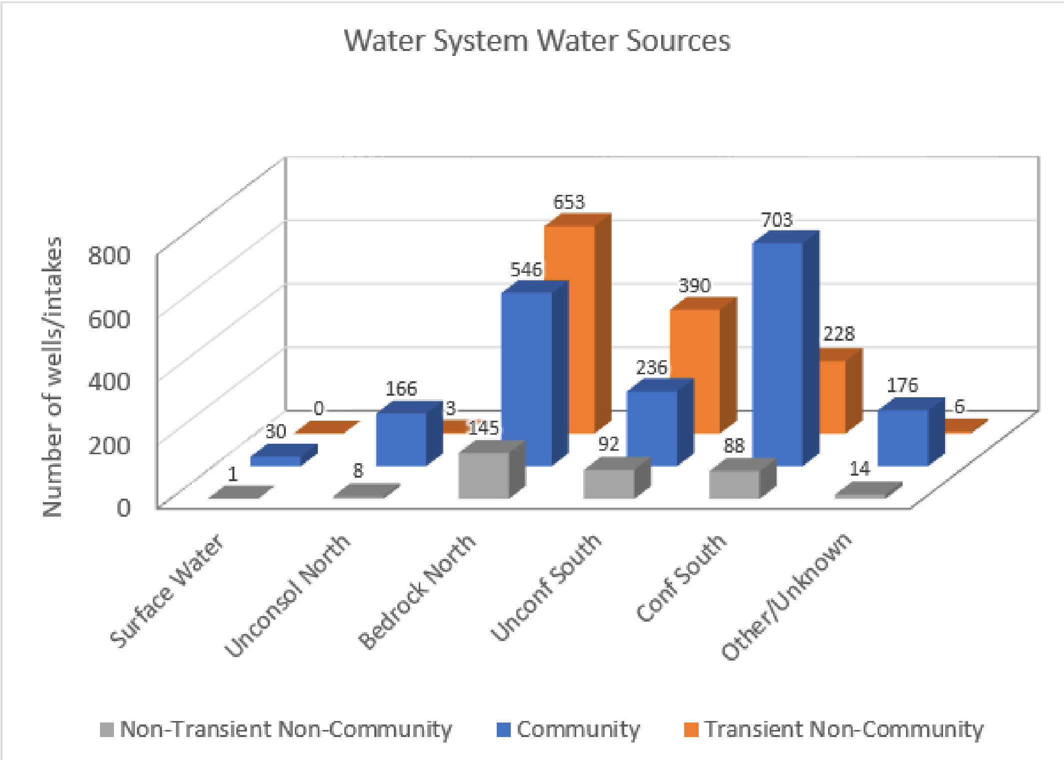


Figure 5.2 Shows number of wells/intakes associated with water systems in the water sources listed.

For this assessment the potable water sources were broken out in the following categories. Surface water includes any intake on a river or reservoir. “Unconsol North” refers to the unconsolidated aquifers located in the Newark Basin, Highlands and Valley and Ridge physiographic provinces and includes primarily sand and gravel aquifers associated with glacial outwash or post-glacial fluvial deposits. “Bedrock North” refers to wells screened in competent bedrock in the Newark Basin, Highlands and Valley and Ridge physiographic provinces. “Unconf South” refers to the unconfined aquifers of the Coastal Plain physiographic province with the most common one being the Kirkwood-Cohansey aquifer. “Conf South” refers to the confined aquifers of the Coastal Plain physiographic province and includes the Potomac-Raritan-Magothy, the Atlantic City 800-ft Sand, and the Wenonah-Mount Laurel aquifers, among others.

Table 5.1 **(Top)** Shows the number of public water systems (by PWSID and including CWS, NTNC and TNC) that apply the treatment objectives listed. Many systems apply more than one objective resulting in total values summing to more than total number of systems.
(Bottom) Shows total number of systems that apply some treatment and total that do not treat. Note that the “no treatment’ systems are still required to monitor water quality and install treatment if necessary. Some of these systems may also be purchasing all their water from a system that does treat its water. This analysis did not account for that situation.

Number PWSIDs	Percentage PWSID Statewide	Treatment Objective
1,239	34.6%	DISINFECTION
767	21.4%	CORROSION CONTROL
720	20.1%	SOFTENING (HARDNESS REMOVAL)
685	19.1%	PARTICULATE REMOVAL
684	19.1%	IRON REMOVAL
213	5.9%	INORGANICS REMOVAL
175	4.9%	ORGANICS REMOVAL
146	4.1%	TASTE / ODOR CONTROL
86	2.4%	RADIONUCLIDES REMOVAL
54	1.5%	MANGANESE REMOVAL
53	1.5%	OTHER
14	0.4%	DISINFECTION BY-PRODUCTS CONTR
2,485	69.4%	PWSID - Treatment of some kind
1,096	30.6%	PWSID – Monitoring, but no treatment
3,581	100.0%	Total PWSID

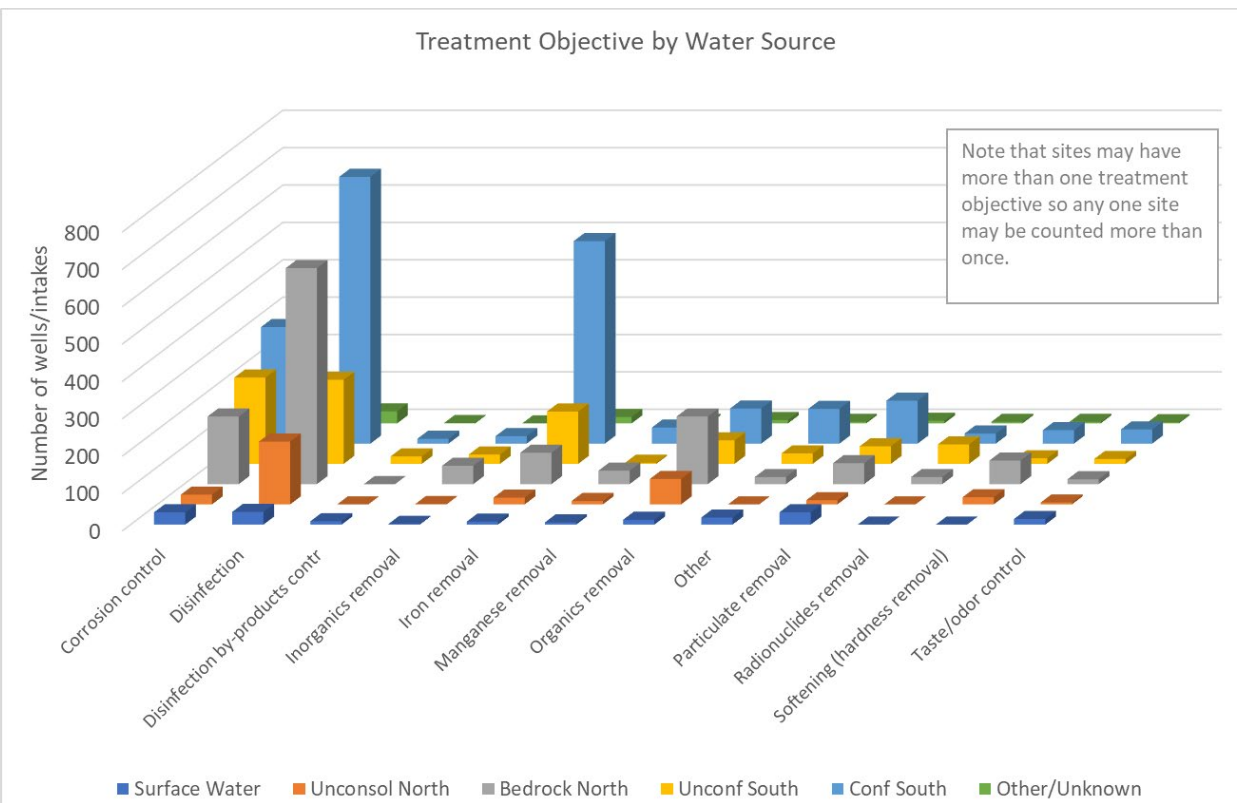


Figure 5.3 Shows the number of wells/intakes where the listed treatment objectives are applied. Data is grouped by water source.

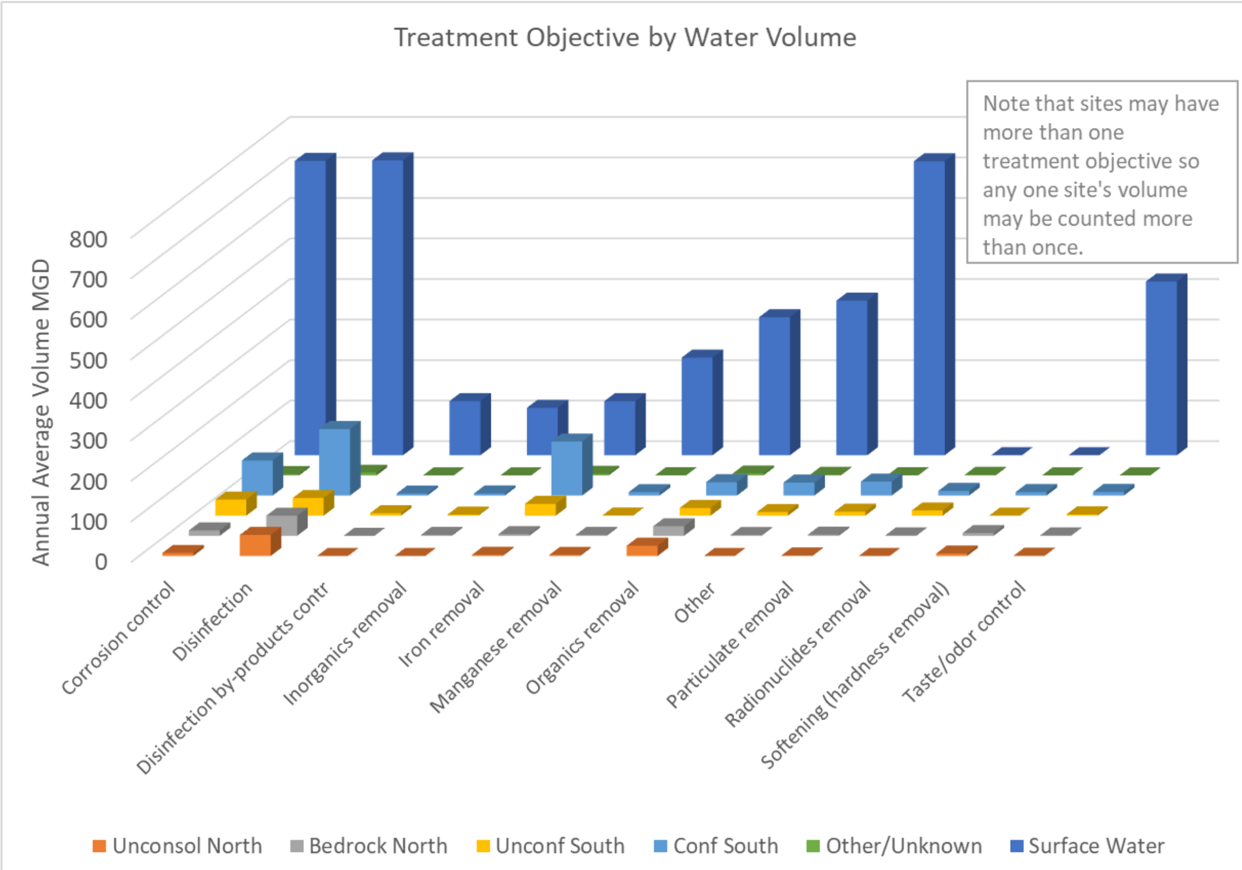


Figure 5.4 Shows the volume of water that undergoes the listed treatment objectives. Data is grouped by water source.

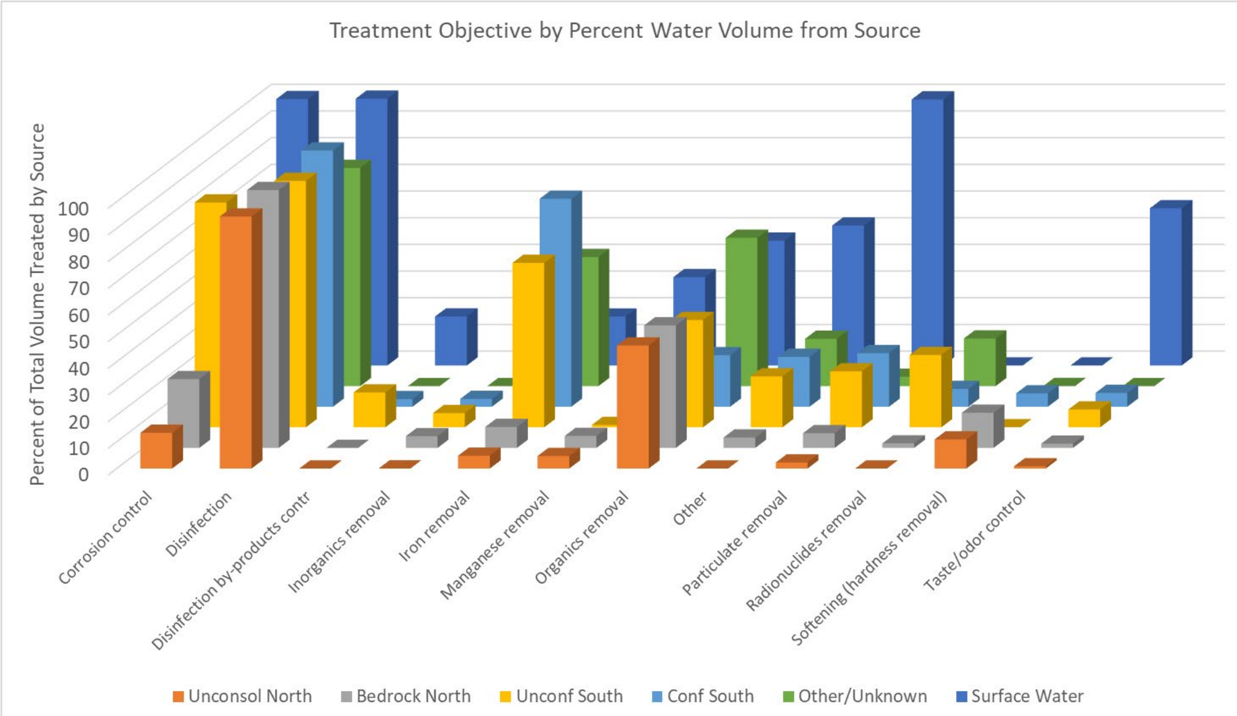


Figure 5.5 Shows the percent volume of water that undergoes the listed treatment objectives for all withdrawals within a given water source.

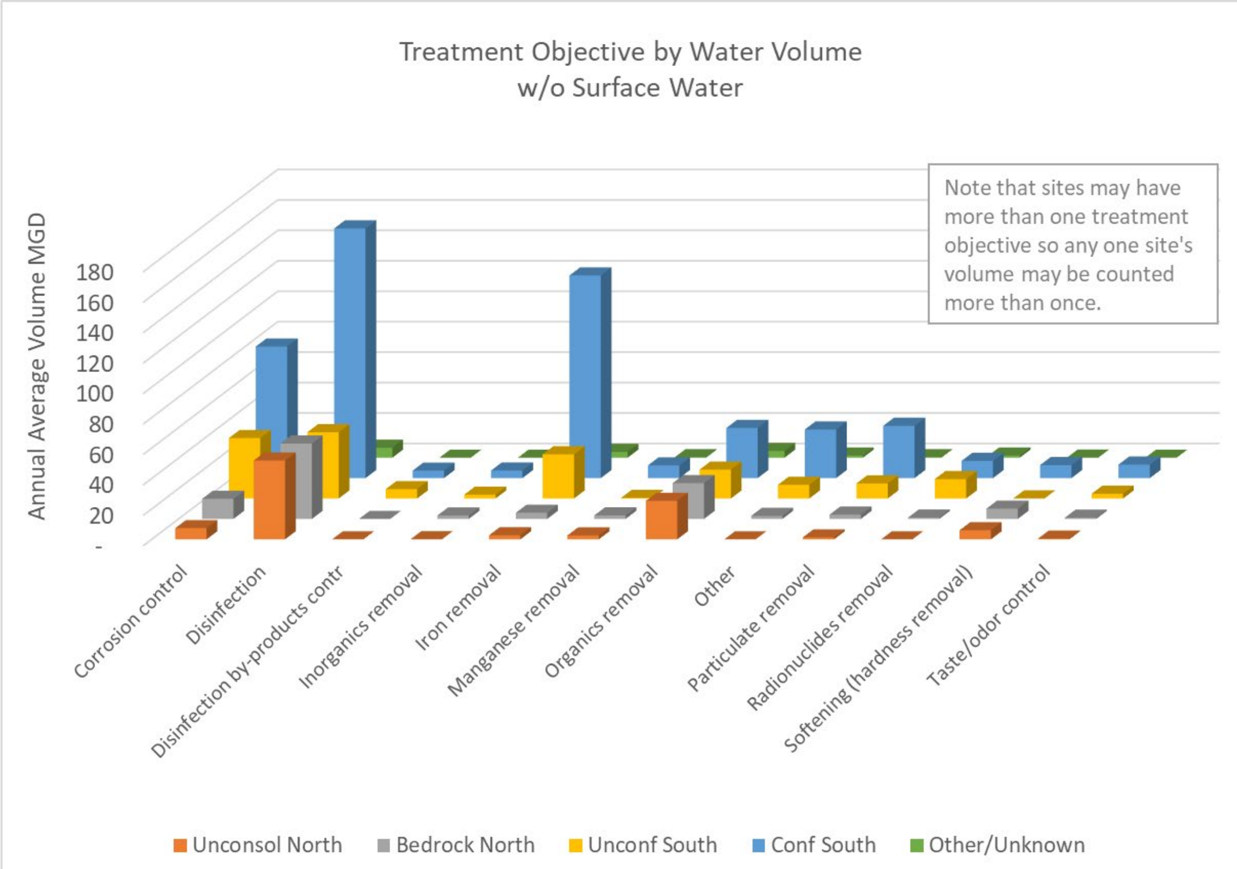


Figure 5.6 Shows the volume of water that undergoes the listed treatment objectives with all surface water removed. Data is grouped by water source.

The following maps show similar information on a subset of treatment objectives and analytes by water system location. These maps are not exhaustive but are included to show the geographic extent of water system service area and drinking water treatment. Note that purchaser systems may be using treated or not treated water.

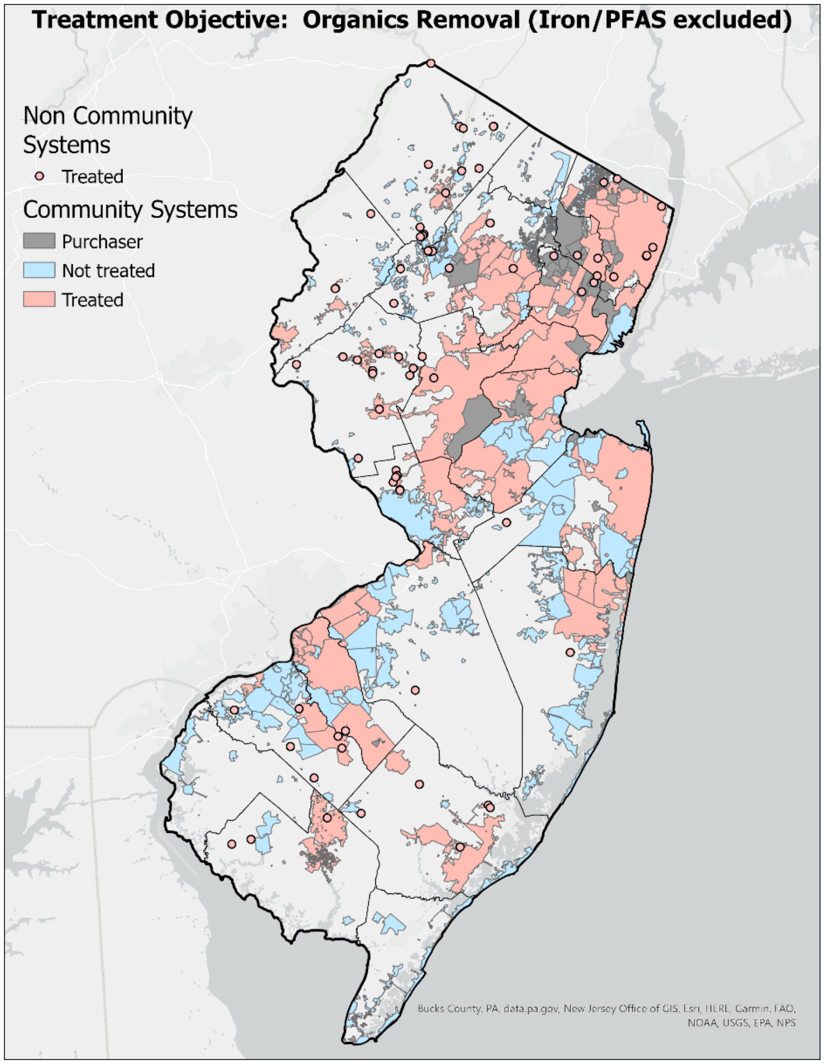


Figure 5.7 Statewide map showing water systems that apply organics removal treatment.

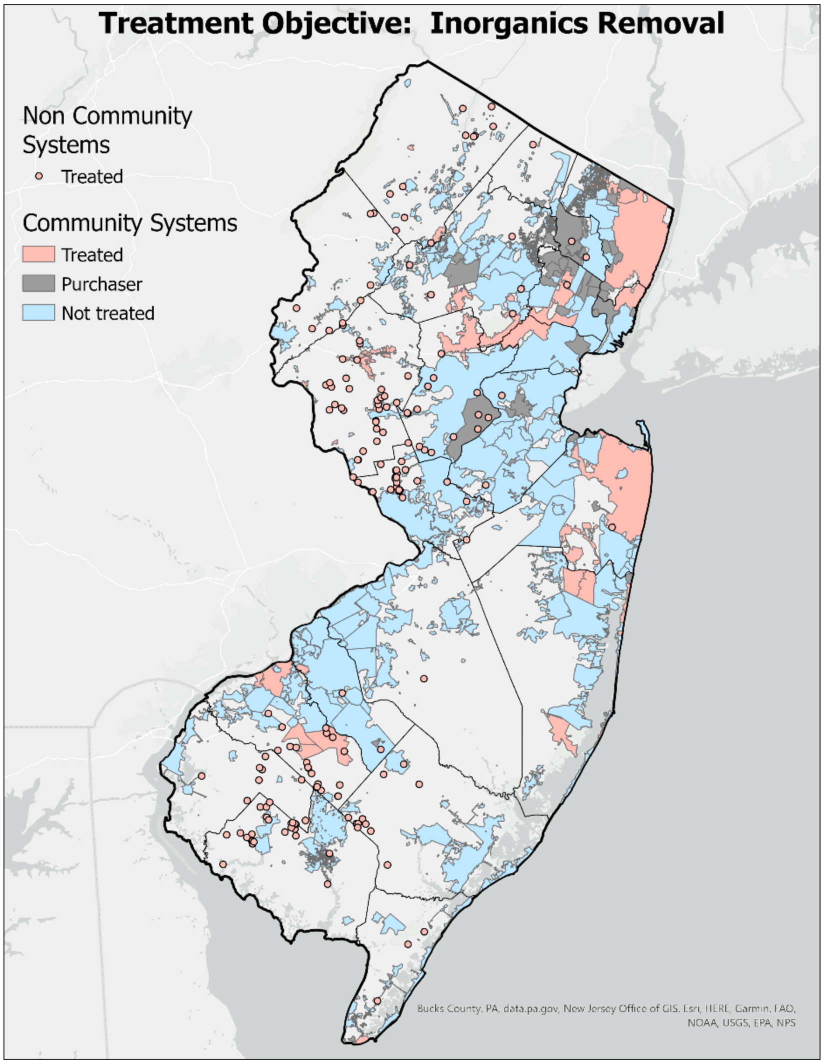


Figure 5.8 Statewide map showing water systems that apply inorganics removal treatment.

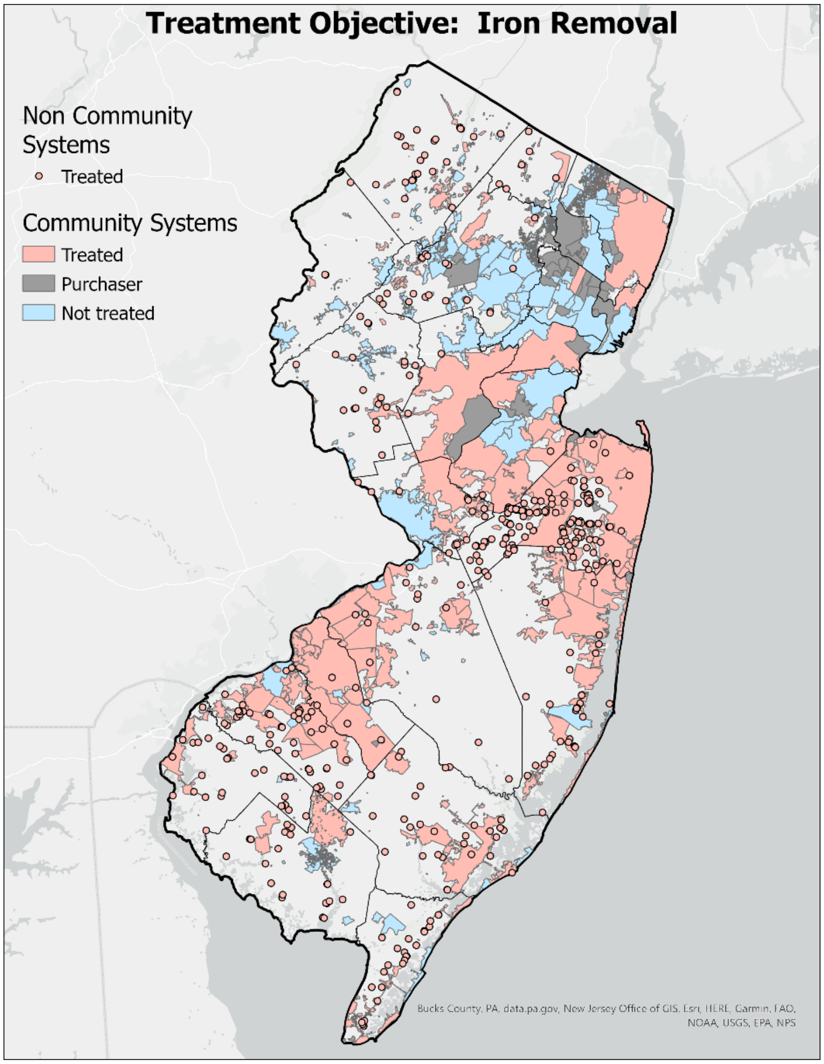


Figure 5.9 Statewide map showing water systems that apply iron removal treatment.

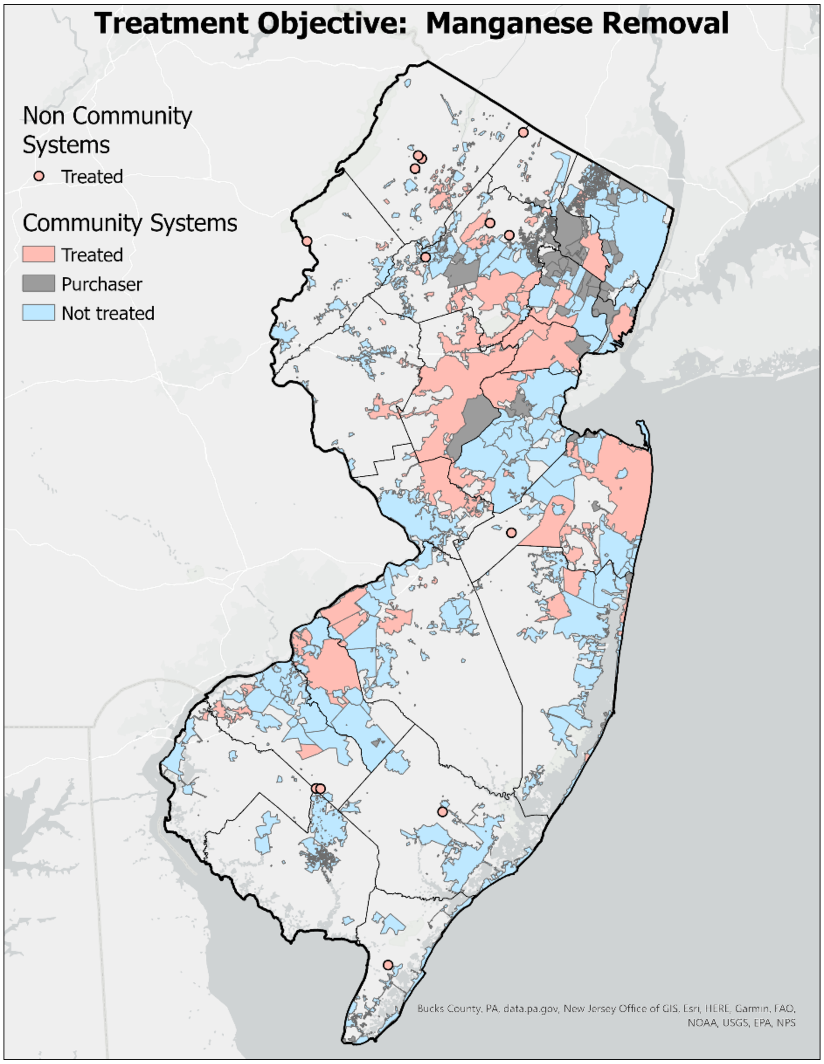


Figure 5.10 Statewide map showing water systems that apply manganese removal treatment.

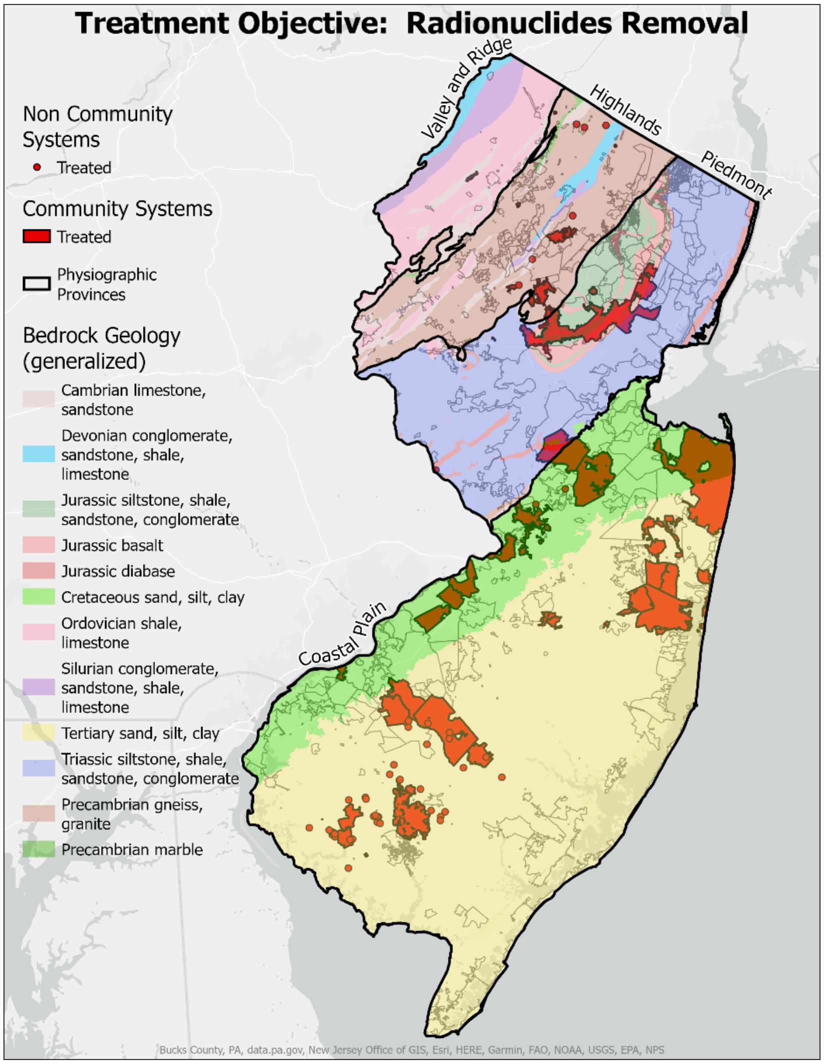


Figure 5.11 Statewide map showing water systems that apply radionuclide removal treatment.

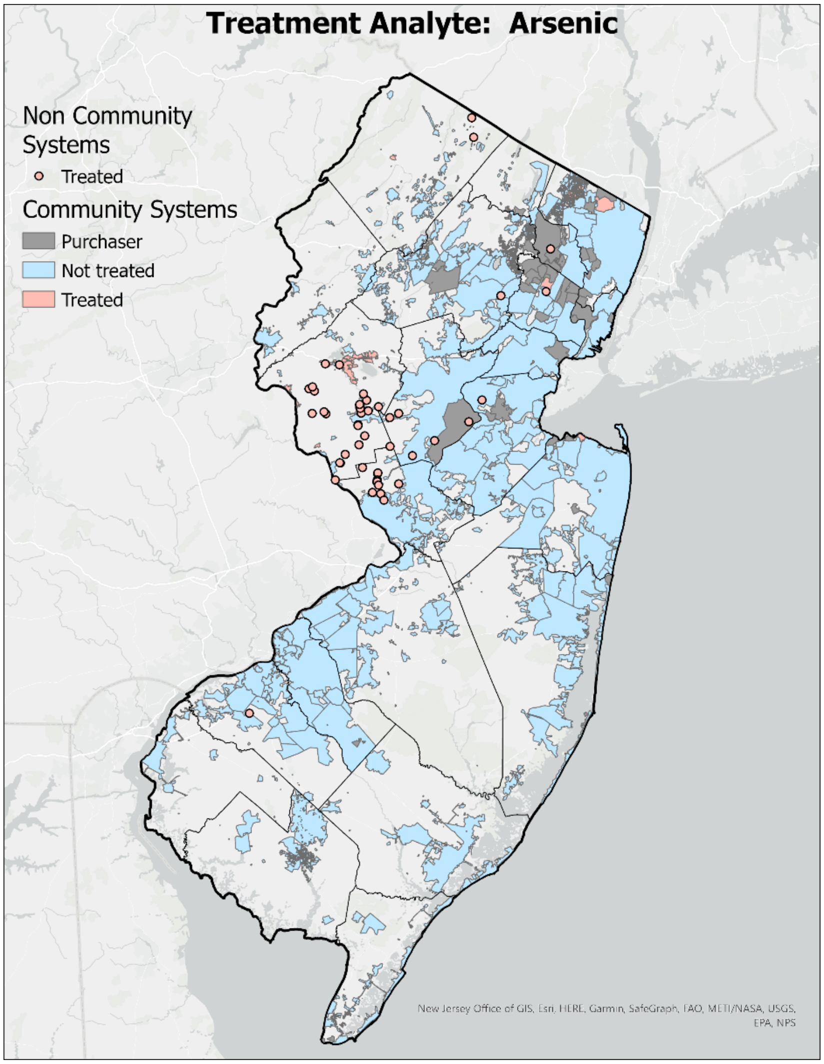


Figure 5.12 Statewide map showing water systems that apply Arsenic removal treatment.

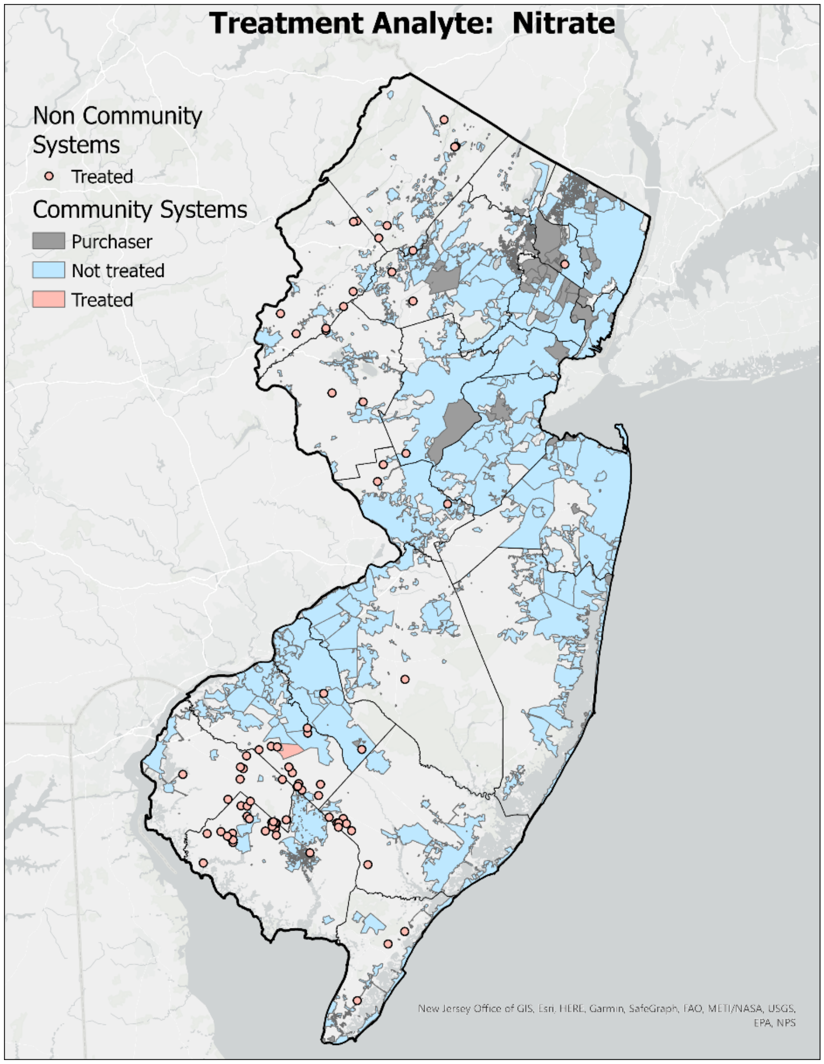


Figure 5.13 Statewide map showing water systems that apply nitrate removal treatment.

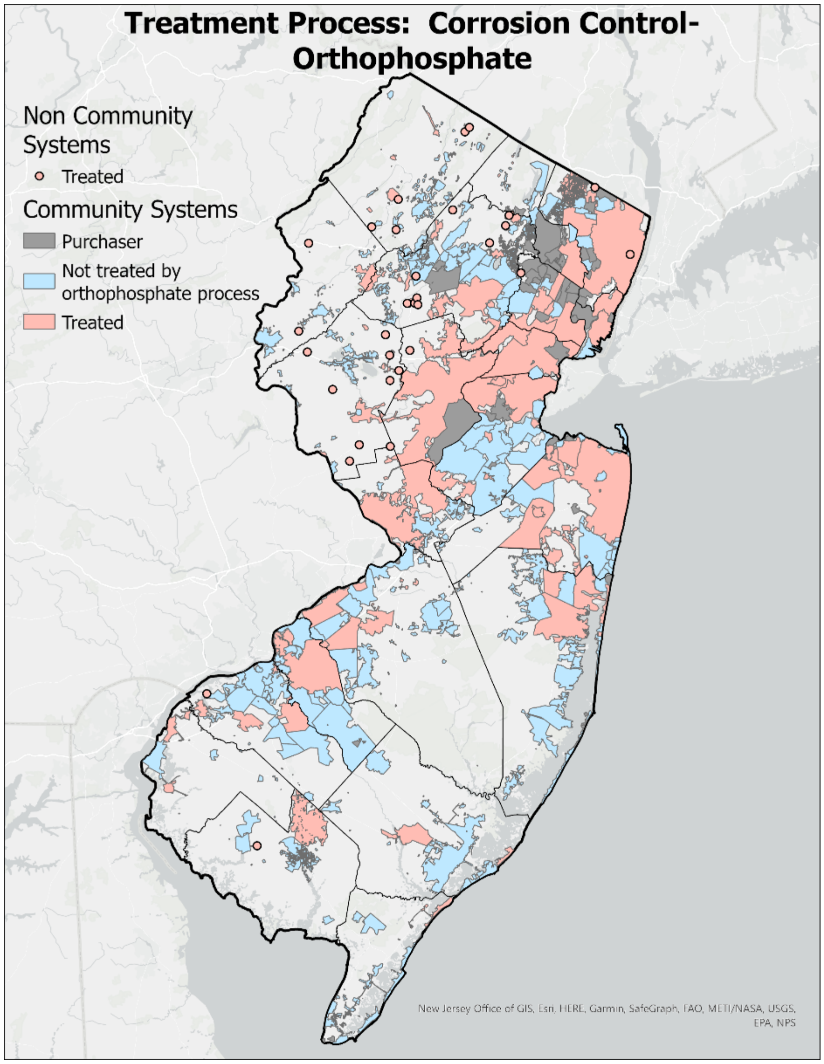


Figure 5.14 Statewide map showing water systems that apply the orthophosphate treatment process to control corrosion.

Through its safe drinking water program DEP works tirelessly to protect the drinking waters of New Jersey. There are many actions that are taken to do so, some of which have been highlighted in this section. DEP is dedicated to ensuring that residents of New Jersey have access to continuous supplies of safe drinking water.

MONITORING AND ASSESSMENT OF WATER RESOURCES

Water resource protection and planning should be based on observed data and sound science. DEP, the U.S. Geological Survey, and other parties such as water supply utilities, have been monitoring New Jersey ground and surface waters for decades, and have developed models to assess data to determine management strategies, such as establishing safe yields and aquifer withdrawal limitations. In water resource and drought monitoring and assessment systems, available measurements, monitoring,

modeling, and trends analysis can be used to understand current and past status. To understand potential future changes, DEP must rely on available data, forecasts, projections, and modeling methods. Discussed below are two forms of DEP water resource and drought monitoring and assessment systems, ambient and drought monitoring and New Jersey Water Transfer Database, with greater detail provided in Appendix L.

- Ambient and Drought Monitoring: As discussed in Chapter 2, DEP maintains extensive ambient and drought monitoring networks. New Jersey's ambient water monitoring program includes four networks that are operated by USGS and are cooperatively supported by DEP. These networks include a stream gauging network, groundwater level network, coastal plain synoptic network, and drought monitoring network.
- New Jersey Water Transfer Database (NJWaTr): The NJWaTr database is primarily funded through the 1981 Water Supply Bond Fund and is used to determine water budgets and water availability estimates for HUC11 watersheds. The database includes approximately 38,000 sites, 24,000 conveyances, and 2.1 million monthly transfers. DEP continuously maintains and updates this database to provide the "living data document" framework envisioned for future water supply planning. Within this Plan, the NJWaTr database was used to create the water budgets and availability assessments in both regional and statewide analyses, including analyses on confined aquifer budgets and HUC11 watershed water budgets. This Plan also included more detailed assessments and modeling efforts conducted by the USGS (under DEP contract) for groundwater systems in the southern part of the State (i.e. Critical Areas 1 and 2, and the confined aquifers).

REGIONAL WATER RESOURCE AGENCIES AND INTERSTATE WATERS

In addition to the water supply planning conducted by DEP, New Jersey is home to several regional and interstate planning agencies that have their own water supply planning programs focused on defined regions within New Jersey. The Delaware River Basin Commission, the New Jersey Highlands Commission and the New Jersey Pinelands Commission have water resource protection, permitting, and planning responsibilities which are discussed below. There are also interstate areas of importance from a water resources perspective that do not have planning agencies solely devoted to their management. These include the Passaic and Hackensack Rivers which receive flows from New York State and the Wallkill River which provides flows from New Jersey to New York State. Finally, there are other programs which have water planning elements focused on New Jersey waters such as the New Jersey Water Supply Authority, the National Estuary Program including the Barnegat Bay watershed. Barnegat Bay is New Jersey's largest enclosed estuary and a major recreational resource that depends on high quality water flows from tributary rivers and streams to maintain its ecological health. In this Plan only the three major water planning agencies and primary intestate waters are discussed, but all water planning across the state and its shared water resources should strive to be consistent and coordinated.

DELAWARE RIVER BASIN COMMISSION

The Delaware River Basin includes a drainage area covering 13,539 square miles. The headwaters of the Delaware River are located in east central New York State and flow generally southward, dividing New Jersey from Pennsylvania and Delaware before emptying into Delaware Bay, approximately 330 miles downstream. The Delaware River Basin Commission (DRBC) was established as part of the Delaware River Basin Compact, a cooperative agreement approved by Delaware, New Jersey, New York, Pennsylvania and the federal government in 1961. The DRBC is charged with the protection of the Delaware River and its watershed. DRBC members include the Governors of the basin states or their designee, and a representative of the federal government (currently from the U.S. Army Corps of Engineers). In addition to its planning and policy role, the DRBC has broad regulatory authority over some aspects of water supply, water quality, flood protection, and watershed management. For more information on the DRBC, visit their website at DRBC.

For surface water and groundwater diversions that require a water allocation permit within the Delaware River Basin as well as NJPDES discharge to surface water permits that discharge to the Delaware River Basin, an Administrative Agreement between the Delaware River Basin Commission (DRBC) and DEP was enacted on December 9, 2015, to provide for a One Process/One Permit Program. In accordance with the agreement, additional requirements are added to water allocation permits and NJPDES permits within the Delaware River Basin. These additional conditions replace the conditions of a DRBC docket where possible, to ensure that water withdrawals do not substantially impair or conflict with the DRBC's Comprehensive Plan. The process avoids duplication and improves efficiency but depending on the type of project, applicants may be interacting with both the DRBC and DEP. As of late 2023, the DEP-DRBC Administrative Agreement was revised to clarify administrative processes and to include underground storage cavern permitting.

A view of the Delaware River from Goat Hill Overlook (located in Lambertville, New Jersey).

The Delaware River Basin Compact provides that no project having a substantial effect on the water resources of the basin shall be undertaken unless it shall have been first submitted to and approved by

the commission (Compact, §3.8). Additional information is available at: DRBC Programs website, DRBC Interactive Map, and DRBC/DEP Administrative Agreement.

Water flow, allocation, and diversions of water from the Delaware River were initially dictated by a 1931 United States Supreme Court Decree. The parties to the Decree are the states of Delaware, New Jersey, New York and Pennsylvania, and New York City. The Decree set limits and conditions for out-of-basin diversions by New York City and New Jersey. In 1954, the Decree was amended to address NYC's continued expansion of water diversions out of the Delaware basin and revised diversions and releases based upon supplies available during the drought of the 1930s (see the Delaware River Master's website at USGS Office of the Delaware River Master for more information on the 1954 Decree).

During the drought of the 1960s, historically the most severe and considered the drought-of- record for the Delaware Basin, the amount of water that New York City's Delaware Basin reservoirs could provide was less than previously calculated. As a result, in 1983 the Decree Parties reached an agreement on a reservoir operating plan for drought and near-drought conditions informally referred to as the "Good Faith Agreement." This work was done under the drought management authorities of the Delaware River Basin Compact and Commission which was created in 1961 and was in its infancy when the 1960s drought occurred.

The Good Faith Agreement has been modified several times to address new issues or incorporate new scientific information. These revisions included improved cold-water fisheries flows modest flood mitigation procedures, and incorporation of hydropower operations. All of the programs agreed to by the Decree Parties since the 1983 Good Faith Agreement were made by unanimous consent and many of them were codified in DRBC's Water Code and in Dockets. In 2007, the Decree Parties instituted a new approach to water management known as the Flexible Flow Management Program (FFMP). The 2017 FFMP remains in effect and includes:

- a ten-year, two-phase agreement that outlined a number of studies that will be undertaken to inform future agreements;
- New York City reservoir releases for upper-basin fisheries based on forecast-based available water;
- a modest degree of uncontrolled spill mitigation (i.e., flood mitigation);
- an increase to New Jersey's Delaware and Raritan Canal (canal) diversion during drought operations.
    - Under non-drought conditions, New Jersey may withdraw 100 mgd from the Delaware River via the canal. While the 1983 Good Faith Agreement limits withdrawals under drought emergencies to 65 mgd, the current FFMP increases such withdrawals to 80 mgd; and
- Minor modifications to the study scopes and timelines were agreed to in May of 2023 at the start of Phase II, however the bulk of the agreement remained unchanged.

New Jersey continues to negotiate with the Decree Parties to restore the right to withdraw a minimum of 85 mgd during a drought emergency, which increasingly plays a critical role in meeting New Jersey's

current and future water supply needs, and enhances water system resilience in the Central, Coastal North and Northeast drought regions. The major HAB event on the Millstone River in the summer of 2022 is a recent example of the critical importance of having the ability to use D&R Canal water during normal and drought periods. New Jersey also continues to negotiate with the Parties to implement regulatory mechanisms to ensure that balanced use by NYC between its Delaware Basin and Hudson basin reservoirs occurs, to not overuse the Delaware sources and unnecessarily cause drought conditions and their associated cutbacks in the Delaware Basin, and to provide saltwater protections to potable intakes and groundwater recharge areas. The mechanisms ultimately agreed to need to balance operational flexibility for NYC but must include 'guardrails' to ensure reasonable protection of all the water users of the Delaware River Basin.

PINELANDS COMMISSION

The Pinelands National Reserve was created by the enactment of Section 502 of the National Parks and Recreation Act of 1978, followed by a State-designated Pinelands Area created by the New Jersey Pinelands Protection Act of 1979.

This internationally significant ecological region covers 1.1 million acres and occupies 22 percent of New Jersey's land area across portions of seven counties (Atlantic, Burlington,Camden, Cape May, Cumberland, Gloucester and Ocean), and is underlain by aquifers containing an estimated 17 trillion gallons of water. It was designated the New Jersey Pinelands Biosphere Region by UNESCO in 1988.

The New Jersey Pinelands Protection Act (P.L. 1979, c. 111) established the Pinelands Commission and charged it with, among other things, developing a management plan to guide future development within the State's Pinelands region -- known today formally as the Pinelands Comprehensive Management Plan (CMP). The CMP sets forth regulations and standards designed to promote orderly development and, at the same time, preserve and protect the significant and unique natural, ecological, agricultural, archaeological, historical, scenic, cultural, and recreational resources of the Pinelands. Residential and other development is limited and directed toward "growth areas" in order to protect the remaining unique, natural, ecological, agricultural, and horticultural resources.

Batsto Village located in the Wharton State Forest in the Pinelands National Reserve. The tea-color water is a natural characteristic of the streams in the New Jersey Pine Barrens.

Certain CMP regulations (N.J.A.C. 7:50-6.86 (a-e)) outline water management within the Pinelands. These regulations address inter-basin transfers, the export of water outside the Pinelands, water allocation and conservation,and criteria for withdrawals from the Kirkwood-Cohansey aquifer. In late 2022, the Pinelands Commission proposed amendments to these provisions of the CMP, to provide "clearer, quantifiable standards for assessing the ecological impacts of non-agricultural diversions from the Kirkwood-Cohansey aquifer…and introducing new, quantifiable standards to protect the available water supply in the watershed in which a diversion will be located…". These standards were then adopted in December of 2023.DEP coordinates with the Pinelands Commission staff to ensure that the water supply permits it issues comport with the CMP goals and objectives.

HIGHLANDS WATER PROTECTION AND PLANNING COUNCIL

The New Jersey Highlands is a 1,343-square mile area in the northwestern part of the State noted for its scenic beauty, water resources and environmental significance. The region includes 88 municipalities in all or parts of seven counties (Hunterdon, Somerset, Sussex, Warren, Morris, Passaic, and Bergen). The Highlands Region is a vital source of drinking water for over 5 million residents both in and outside of the Highlands. The Highlands Water Protection and Planning Act (Highlands Act), N.J.S.A. 13:20-1 et seq., was signed into law on August 10, 2004.

Monksville Reservoir located in Long Pond Ironworks State Park in the New Jersey Highlands.

Specific to water supply management, the Highlands Act rules (N.J.A.C. 7:38) limit the issuance of water allocation permits to projects that are exempt from the Highlands Act, or to those projects for which a Highlands Preservation Area Approval with waiver has been issued. The rules also include standards for water supply diversion sources where a diversion source is located within the preservation area, and PCWS serving authorized development in the preservation area (N.J.A.C. 7:38-3.2 and 3.3 respectively). The Highlands Act also amended the Water Supply Management Act to prohibit the DEP from issuing Water Allocation and Registration permits that are inconsistent with the Act and Highlands Regional Master Plan. Within the Preservation Area, the regulatory threshold of 100,000 gallons per day (3.1 million gallons per month) for a water allocation permit was reduced to 50,000 gallons per day (1.55 million gallons per month). DEP has and will continue to coordinate and cooperate with the Highlands Water Protection and Planning Council on water supply related decision making.

INTERSTATE WATERSHEDS: PASSAIC, HACKENSACK, AND WALLKILL

New Jersey receives river flows from New York State primarily through watersheds of the Hackensack River (from Rockland County) and the Wanaque, Ramapo and Mahwah Rivers (from Rockland and Orange Counties), New York State receives river flows from New Jersey through the Wallkill River in Sussex County.

The Passaic and Hackensack watersheds are of critical importance to water supplies in northern New Jersey. Several of the six major surface water systems rely in part of interstate water flows: the North Jersey District Water Supply Commission's Wanaque System, Passaic Valley Water Commission's Passaic River System and Veolia New Jersey's Hackensack System. These and the other three major systems (Newark's Pequannock System, Jersey City's Rockaway System, and New Jersey American Water Passaic System) are highly interconnected to allow the systems to transfer water under normal conditions, in the event of a water supply emergency, or in response to the uneven effects of droughts. Interstate flows along the Ramapo River also help support aquifer resources in the Oakland and Mahwah area.

The Wanaque Reservoir located along the Wanaque River in Wanaque and Ringwood, New Jersey. In addition to being located in the New Jersey Highlands, the Wanaque River is a tributary of the greater Passaic River watershed, which includes areas in both New York and New Jersey.

Written agreements exist between the two states to ensure that specific minimum river flows are met for the Ramapo and Hackensack Rivers, but lack of agreement formalization into legal documents has resulted in differing and inconsistent interpretation of required actions. Additionally, continued development in the New York portions of the watersheds can result in lower annual flows, even when the required minimum flows are met. At times, Rockland County has considered water supply projects, new consumptive use or wastewater exports to the Hudson River, that could threaten flows into New Jersey. Significant growth is projected for parts of Orange and western Rockland Counties. Additionally, there are contamination issues in aquifers along the Ramapo River in the Suffern, NY, area as well as surface water quality changes, e.g., nutrients, that can result in drinking water treatment difficulties for downstream intakes. It is not clear if the past written agreements have been carried forward in New York State water permits or are actively utilized currently. For this reason, DEP monitors potential issues that might harm New Jersey water supplies.

The Hackensack River faces similar interstate management issues. The main example is Veolia NY's reservoir, DeForest Lake and the Town of Nyack diversion in Rockland County, both of which are upstream of and control flows to Veolia New Jersey reservoirs- Lake Tappan and the Oradell Reservoir.

With water supply reservoirs on both sides of the border, different operating water utilities and multiple state and local regulations, water management is complicated and past agreements to share water have not always been interpreted in similar manners. This issue is also monitored as needed by DEP. Preliminary RiverWare modeling analysis indicates that there may be alternative reservoir management scenarios in the Hackensack River basin that could increase the safe yield of the Deforest Reservoir and improve water supply reliability in New Jersey without creating new problems. DEP should consider working with New York government authorities and water utilities to see if agreement or management plans can be agreed to.

The Wallkill River watershed flows in the other direction, starting from Lake Mohawk in Sparta and going north into Orange County, New York. No New York reservoirs are fed by the Wallkill River, but several small towns are located on its length. To date, no interstate issues have been raised and no minimum flow agreements exist, but should additional New Jersey demands threaten flows into New York, issues could arise.

SUMMARY

DEP's comprehensive water resources management aims to provide a holistic approach to managing the state's water resources. This includes providing protection of water quality and supply, allocation to users, safe drinking water, and infrastructure regulation and financial assistance from a supply, standards, and monitoring perspective. DEP must operate not only under general and legislative authority, but must also coordinate its efforts with regional authorities, such as the Delaware River Basin, Highlands and Pinelands Commissions, which carry out their own planning processes based on their associated regulations and statutes.

The Delaware and Raritan Canal at Swan Creek located in Lambertville, New Jersey.

DEP works to not only promote water use efficiency and conservation, but also encourage water system resilience and asset management. Current DEP actions encouraging statewide water conservation include: (a) the implementation of the New Jersey Water Savers program; (b) ongoing efforts to improve access to PCWS water loss data to reduce non-revenue water losses; and (c) its collaboration with Sustainable Jersey to create an Outdoor Water

Conservation model ordinance for municipal consideration. DEP has also pursued efforts to increase statewide water system resilience. With the WQAA setting new requirements for purveyors of public water systems to improve their water infrastructure, DEP continues to promote water system resilience by continuing its collaboration with water purveyors to implement asset management requirements for the WQAA and monitoring emergency agreements between purveyors, along with continuing its implementation of recommendations from the *2007 Statewide Interconnection Study*. DEP also continues to pursue efforts to increase the resilience of public water systems by considering new and potentially expanded sources of water supply.

DEP implements the New Jersey Safe Drinking Water Act by using a multi-barrier approach starting with water source protection, since treatment systems will be more successful if incoming source waters are high quality. To implement the Safe Drinking Water program, DEP's Division of Water Supply and Geosciences is responsible for regulating and guiding the proper operation of New Jersey's public water suppliers, and DEP works with drinking water utilities during emerging water contamination issues, including line breaks and water pressure problems. As shown in the Statewide Safe Drinking Water Assessment sub-section, many actions and treatment processes are conducted by public water systems to ensure that residents of the state have safe drinking water.

DEP's holistic approach to managing the state's water resources also aims to address potential environmental justice concerns related to water supply. Many PCWSs with large numbers of overburdened communities are located in historic urban centers and may face challenges in the future, such as rate increases or stress from trying to meet water demands. Also, as numerous overburdened communities are located outside of PCWS service areas, residents may not have the financial resources to conduct adequate system maintenance and regular testing of private wells or for small isolated PCWSs. This may make them more vulnerable to experiencing negative health effects if contamination of their water supply were to occur. Climate change may also present additional financial challenges for PCWSs with large numbers of overburdened communities as they may have difficulties in raising rates to pay for good asset management in normal times and responding to disaster response costs during emergencies.

Preventing and mitigating inequities in affordability related to water supply may take on several different forms, including DEP's ongoing efforts to provide low-interest financing of water infrastructure projects through resources, such as the New Jersey Water Bank and the Drinking Water State Resolving Fund, to reduce costs to ratepayers. Currently, there is no permanent state or national program to assist customers so PCWSs can set rates at viable levels that consider customer income levels. Recommendations were proposed for improving state assistance to overburdened communities regarding their water supply include: (a) DEP potentially working with NJDOH, NJDCA, and local and county health officials to conduct further research on the financial needs of low-income private well owners, and (b) Legislature potentially considering the appropriation of a supplemental fund to support low-income residents for the replacement of failing wells due to age or the installation of treatment for naturally occurring contaminants.

DEP has been working with USGS, water supply utilities, and other organizations to monitor New Jersey's ground and surface waters for decades and has developed models to guide the development of water

resource protection and management strategies. DEP maintains an extensive ambient and drought monitoring network, which includes data from four networks (stream gauging network, groundwater level network, coastal plain synoptic network, and drought monitoring network) that are operated by USGS and cooperatively supported by DEP. The New Jersey Water Transfer database is also used by DEP to create water budgets and availability assessments for both statewide and regional analyses. This includes USGS detailed assessments and modeling efforts for groundwater systems in the southern part of the state that are provided in this Plan.

Specific areas DEP intends to target related to its comprehensive water management approach include:

- continuing ongoing efforts to expand its existing safe yield models to address all surface water systems, including interconnection flow scenarios with the goal of improving operation and coordination between water systems during both normal and emergency conditions;
- reviewing and evaluating Water Allocation rules at N.J.A.C. 7:19 2.2(i) to enhance current Water Conservation and Drought Management Plans and considering amendments to update existing water supply emergency management procedure rules (N.J.A.C. 7:19);
- continuing to develop, encourage and implement where appropriate, water conservation and water use efficiency to preserve supplies, increase resilience, and minimize costs;
- continuing to support, expand, fund, and require (where appropriate) asset management and enhanced water resource and infrastructure resilience;
- continuing to expand the water supply OBC analyses to better define issues, needs and appropriate actions;
- continuing to support and expand the water resource monitoring networks and assessment research and models (could include expanded assessment of drinking water treatment applications used by water purveyors); and
- Source Water Assessment Program updates that improve coordination and integration with other water quality planning and protection programs in the DEP and which ultimately improves drinking water quality treatment efficacy.

CHAPTER 6: REGIONAL PLANNING FOR DEFICIT MITIGATION AND AVOIDANCE

TABLE OF CONTENTS

OVERVIEW

A primary purpose of statewide water supply planning is to identify specific areas where existing or potential future withdrawals do or may exceed available natural and constructed water supplies, especially during dry periods. In accordance with the Water Supply Management Act as well as common understanding, running out of water is not acceptable, and damaging ecosystems by withdrawing too much water is also not acceptable. This chapter discusses a general framework for risk assessment and a process for regional planning and management that has previously been used region-by-region but not formalized. This chapter also addresses various regions of New Jersey where DEP assessments or the statewide evaluations discussed in prior chapters have identified one or more

Beach vegetation and a beachfront community located in Ocean City in Cape May County, New Jersey. Some locations in Cape May face challenges from saltwater intrusion into their water sources.

factors (e.g., demands, supply limitations, ecological concerns, supply contamination) that indicate a need for more detailed, regional analyses and responses or where specific water allocation restrictions are warranted. The framework is applied to each of the regions discussed, providing a sense of where the region is within the planning process- from early efforts to completed management actions.

Water supply planning or management strategies are not a one-size fits all approach or contained within defined boundaries. Varying severities of resource stress and breadth of issues affect regions differently and require specific planning approaches. This section addresses the areas of concern as they were identified in previous planning efforts as well as new areas of concern with newly defined boundaries.

RISK ANALYSIS APPROACH IN REGIONAL PLANNING

Not all indicators of water supply stresses are the same, nor are the uses of these indicators. Planning programs may use indicators differently than regulatory programs. The Plan assesses stresses using a hierarchy of indicators, as applied through a matrix that assesses certainty of the indicators against the severity of indicated stresses. This section briefly discusses this approach and how it applies to identified water stress issues.

INDICATORS OF WATER SUPPLY STRESSES

Water availability indicators are useful in assessing current and potential future conditions. For both, indicators may reflect physical or ecological parameters. The following table shows a variety of indicators and the methods used to measure their current or future status.

Table 6.1 Shows analytical methods applied to listed indicators to measure current and future stresses.

Indicator	Analytical Methods (Current Stresses)	Analytical Methods (Future Stresses)
Reservoir levels	-In-situ measurement, past trends, reservoir curve comparisons	-Safe yield models-simple -Safe yield models-sophisticated with climate change
Unconfined aquifer levels	-Static water level measurements, past trends	-Low Flow Margin methodology -Regional aquifer models -Land Phase model with climate change
Stream flows	-In situ measurement, past trends	-Low Flow Margin methodology -Land phase model with climate change
Confined aquifer pressure (potentiometric surface levels[1])	-Static water level measurements, past trends	-Confined aquifer models

[1] The potentiometric surface is the level to which water will rise in tightly cased wells that withdraw from a confined aquifer. It reflects the pressure on water in the confined aquifer. The potentiometric surface is for a confined aquifer similar to the water table for an unconfined aquifer.

Indicator	Analytical Methods (Current Stresses)	Analytical Methods (Future Stresses)
Aquatic ecosystem integrity	-Macroinvertebrate analysis, stream channel assessments (SVAP, etc.), Fish IBI analysis	-Low Flow Margin methodology

Some of these methods provide a stronger validation of indicator status than others. In general, lower certainty is associated with models that are based on statewide statistical analyses, which are used where direct data are not available and characterizations of hydrologic parameters for some water resources must be applied to all water resources. Higher certainty comes from resource-specific measurements and models calibrated and validated using data from that water resource. Models of future conditions are inherently uncertain, as assumptions must be made regarding how future conditions may be different from current conditions, such as populations, demand patterns and climate conditions influenced by climate change.

Data also have varying levels of certainty, based on the measurement frequency and record length (longevity) relative to the inherent variability of what is being measured. For example, agricultural withdrawals are usually estimated by multiplying pump capacity by hours of operation, rather than by in-line metering that would be more accurate but more expensive and not required by law. A second example is stream flow, which is inherently variable and therefore must be measured frequently and for extended periods to yield valid statistics. Periodic monitoring provides less certainty than continuous monitoring.

These uncertainties are a major reason why this Plan is periodically updated, so that additional data, better forecasting assumptions and improved models can be applied to water resource issues.

LEVELS OF CERTAINTY IN WATER SUPPLY STRESSES

Using the indicators and analytical methods outlined above, it is possible to identify a hierarchy of analyses that show potential or validated stresses (or lack thereof).

- Potential Stress or Surplus: A water availability deficit or surplus is indicated by generalized statistical modeling (e.g., LFM method; simple aquifer models; simple safe yield models), but direct measures of water resource stress trends have not been carried out, such as measurements of local stream flows, water table measurements from specific unconfined aquifers or potentiometric surfaces from specific confined aquifers. At this level of analysis, absence or presence of a small stress or surplus is not definitive, especially where monitoring data may be of questionable accuracy level. The higher the deficit or surplus, the more likely the finding is qualitatively correct regarding the direction and general magnitude of the result.
- Validated Stress or Surplus: A water availability deficit or surplus is shown by resource-specific models based on local, validated data (e.g., USGS or NJGWS aquifer models; reservoir systems safe yield models using RiverWare or similar software; LFM results based on updated NJWaTr data and water monitoring data such as stream flow trends and groundwater levels) that show a clear deficit or surplus; especially, a result that exceeds the understood uncertainty of the model.

Another validation approach involves use of longitudinal trends in stream flows, water table measurements or potentiometric surfaces that have demonstrated declines or increases correlated to consumptive and depletive water uses.

- Validated, Highly Stressed: In addition to the modeling approaches discussed for validated results, a high stress is indicated where longitudinal data from trends in stream flows, water table measurements or potentiometric surfaces have demonstrated long-term, rapid short-term or other major problematic declines related to consumptive and depletive water uses.

APPLICATION TO KNOWN WATER AVAILABILITY ISSUES

Based on the discussion above, Table 6.2 presents a variety of water availability issues, with certainty ranging from high to low and severity from minimal to high. In each case, Blue text indicates that the issue has been resolved (no water availability deficit or the deficit has been eliminated or is actively managed), and Orange text means that the issue is not resolved (a deficit is indicated or validated and still exists). Conceptually, this matrix maps water supply risks. Issues in the top left (High Certainty, Minimal Severity) need minimal planning attention. Issues at the lower right (Low Certainty, High Severity) are strong candidates for extensive research. Issues at the upper right (High Certainty, High Severity) should be the focus of immediate management attention if not already addressed.

Table 6.2 Matrix displaying certainty vs. severity with water availability issues to serve as examples

Certainty of Measurement	No Concern or Minimal Severity	Moderate Severity	High Severity
High (fully validated)	-Raritan System Safe Yield	-Cape May Saltwater Intrusion	-WS Critical Area 1 -WS Critical Area 2
Moderate (modeled or trend results)	-HUC11s with Positive or Minimal Negative LFM Water Availability -Current impacts to water availability from climate change	-NE-NJ Safe Yield (no deficits but drought sensitive) -HUC11s with Negative LFM Water Availability	-Loss of water availability from contamination
Low (preliminary results)	-Current system drafts exceeding permitted safe yields	-Short-term (to 2028) climate change impacts to water availability	-Medium to long-term (2050-2100) climate change impacts to water availability

FRAMEWORK FOR REGIONAL WATER SUPPLY PLANNING AND MANAGEMENT

The statewide water supply planning process since 1981 has identified multiple regions with confirmed or potential water supply deficits that could constrain water demands (e.g., potable, agricultural, industrial)

or put aquatic ecosystems at risk. Some of these regions have been addressed through initiatives to control or reduce water demands, increase or replace water supplies, or both. In other regions, additional research has helped better understand the certainty and severity of the potential deficits.

The following general approach is intended to address regions at least tentatively identified as having water supply stresses. The approach is a stepwise effort to improve certainty, evaluate severity, identify remedial options, and then track progress toward avoidance, mitigation, or elimination of deficits. Efforts in specific water supply regions may already have addressed one or more of these steps.

All regional planning efforts should include engagement with agencies, organizations, and representative public individuals who can help DEP understand the target region, data issues, analytical issues and remedial options. Engagement should start early in the planning process so that key interests understand the nature and potential uncertainty of the issue and data and analytical approaches used, so that they may be effectively involved in development of viable responses.

Step 1: Data Verification

All regional analyses (e.g., Low Flow Margin approach, confined aquifer models, safe yield models) use the best data available at the time of development. However, each data source will have different uncertainties, as discussed in the previous section. For example, continuous stream flow gauging stations have higher certainty than periodic flow measurements; metered agricultural withdrawals will have higher certainty than withdrawal estimations. In addition, new data may be available for models that have not been recently updated. Finally, no database is perfect, and so verification of existing information may be appropriate. To address these issues, this step involves an analysis of the data used to assess whether more current or accurate data may be available or necessary to confirm water resource stresses.

Step 2: Model Reanalysis

All water supply models are approximations of reality based on available data, statistical analysis, mathematical representations of system interactions, and interpretation. Even highly sophisticated modeling software faces limitations such as incomplete datasets or imperfect hydrologic knowledge. For aquifer modeling, boundary conditions (i.e., the potential for water flows between aquifer units or between aquifers and surface waters) create modeling complications as well.

Therefore, all models have some uncertainty associated with their results. In general, models built to assess specific resources using local data, such as for reservoir safe yields or confined aquifers, will have more robust results than models that use large scale (e.g., statewide) approaches to assess local resources.

This step involves an analysis of the model(s) used for the initial assessment and the extent to which modeling is reliant on local data and purpose-built approaches, and whether improved modeling will be needed to better understand the potential for water supply stresses. Hydrologic modeling is complex so choosing the best model can be difficult, but not impossible. The DEP will utilize industry best practices and standards, experience, and outside state and/or federal agencies as benchmarks for decision making.

Step 3: Regional Evaluation

Water demands are in large part a function of land uses and human needs. Regional water supply planning occurs within this broader context. This step involves evaluation of existing and potential regional land uses, geography, demographics, and water demands, compared to the existing water availability. The purpose of this step is to assess the potential for increased or decreased future demands, water quality impacts of existing and future development, and hydrologic changes related to land use development and redevelopment.

Step 4: Enhanced Monitoring, Modeling and Analysis

Where the first three steps support a concern that the water demands may exceed water availability, but the assessment has insufficient certainty to justify management or regulatory actions, development of a more detailed water availability analysis may be appropriate. This step could include one or more of the following:

- Additional data from existing or new monitoring points to support an existing or improved model. For example, additional years of stream flow or aquifer level data may provide improved statistics for use in a model.
- Enhanced modeling: For example, where a statewide modeling approach indicates a concern regarding an unconfined aquifer/surface water system, development of a local or regional model could provide more accurate result for the specific regional resource.
- Enhanced analysis: Model results can be combined with other information that allows a broader and more useful context for determining whether and to what extent a regional water supply problem exists or will occur. Climate change impacts will be one consideration for model improvement, as new information is available.

Step 5: Planning, Management, and Regulatory Responses

With a solid basis for determining that a regional water supply problem exists, the next step is a planning process to determine the appropriate management and regulatory responses to avoid, mitigate or eliminate the problem. A good example is the reduction of confined aquifer withdrawals in Water Supply Critical Areas 1 and 2, which occurred through implementation of amendments to the Water Supply Management Act during the late 1980s in response to signs of aquifer depletion. Reduced withdrawals were replaced by new surface water supplies where environmental concerns were reasonably mitigated. Methods could include:

- establishment of resource-specific water resource objectives, such as confined aquifer levels, consumptive and depletive use limitations, or stream flow patterns;
- demand management, such as water allocation or certification restrictions for specific water resources, utility water loss reductions, water conservation initiatives by water users, and land use controls such as zoning modifications and site development requirements;
- supply management, such as shifting demands between available supply points; or
- supply augmentation, such as reservoir construction or expansion or use of MAR.

Step 6: Progress Evaluation

Finally, periodic reexamination of the regional issue is important to determine whether the planning, management and regulatory responses achieved the intended results. Examples include the calculation of new safe yields subsequent to addition of a surface water reservoir, periodic reports on the confined aquifers in Water Supply Critical Areas 1 and 2, or maintenance of appropriate stream flows during critical low flow periods. The reexamination can then identify a need for new work in any of the prior steps, including modifications to the management approach, or it may determine that all objectives are being or have been achieved. If the water resource objectives have been permanently achieved, no further region-specific evaluation may be needed, but continued monitoring would be needed to ensure long-term compliance with the objectives. Where objectives are not yet met, or achieved objectives may not be permanent, then periodic reexaminations are appropriate.

WEB-BASED RESOURCES AND APPLICATIONS

The DEP continues to provide GIS and other online resources to assist water users, planners and managers in decision making. These resources are available from a host of web locations. Of specific interest to this Plan and this chapter are the following online resources:

Water Use Data: Available to the public is an online interactive ArcGIS product called "New Jersey Water Withdrawal Data Summary Viewer". The interactive map allows users to select, plot and download water withdrawal data by either municipality or 14-digit hydrologic unit. It provides an alternative way of viewing withdrawal data that is also included in the DGS13-1 Computer Workbook Summarizing New Jersey Withdrawals and Discharges on a HUC11 Basis and utilizes the same data available from the DEP NJGS DGS10-3 website. Data can be viewed statewide or by selecting one or more of the geographic divisions. Downloads, in CSV format, are reflective of municipality or HUC14 selection. Data can also be sorted by source of water (e.g. groundwater, surface water, etc.) or by use of water (e.g. potable, agriculture, power generation, etc.). The dashboard can be viewed at New Jersey Water Withdrawal Data Summary Viewer (arcgis.com). This new graphical and interactive format should increase user access and accessibility.

HUC11 Drainage Basins: The DEP's interactive mapping tool developed by the Bureau of GIS can be used to identify the location of a specific municipality in relation to one or more of the State's 151 onshore HUC11s. Access to this tool can be gained through the following link: Bureau of GIS NJ-GeoWeb. Many other data layers are available from this resource.

New Jersey Geology Information App: Most of the geographic regions and water resources identified in this chapter can be mapped and accessed from the New Jersey Geology Information App which contains information on geology, hydrogeology and ambient water quality data through its interface.

WAAS Tool: Of specific relevance to this Plan and chapter is the Water Allocation Availability Screening Tool (WAAS). This tool is hosted in the New Jersey Geology Information App. It can be launched by selecting the hammer icon located in the upper right-hand corner of New Jersey Geology Information App

webpage. The WAAS Tool launches a python script to compare a user defined state plane coordinate against many water allocation areas of concern identified here in Chapter 6.

Several regions of New Jersey are areas for intensive planning and management efforts regardless of whether the waters within them are identified as having potential or validated water availability constraints. Two of these regions, the Highlands Region of northern New Jersey and the Pinelands Region of southern New Jersey, have special state agencies tasked with planning for and protecting water and ecological resources while providing for compatible development, the Highlands Water Protection and Planning Council and the Pinelands Commission, respectively. The Delaware River Basin is of national importance, as the focus of an interstate compact agency, the Delaware River Basin Commission, and a U.S. Supreme Court order regarding the allocation and management of water supplies in the basin for New York City and the four basin states. An overview of their water supply planning responsibilities is discussed below, and more detailed information can be found in Chapter 5.

REGIONAL PLANNING AGENCIES

DELAWARE RIVER BASIN COMMISSION

Article 3 Section 3.2 of the Delaware River Basin Compact directs the Commission to formulate and adopt "[a] comprehensive plan, after consultation with water users and interested public bodies, for the immediate and long-range development and uses of the water resources of the basin..." DRBC has developed numerous plans since it was established in 1961 and the Water Resources Program Report released in June 2023 (Water Resources Program FY 2024-2026 Report) documents recent activities to meet the goals of their 2001 Comprehensive Plan (DRBC 2001 Comprehensive Plan).

HIGHLANDS WATER PROTECTION AND PLANNING COUNCIL

The Highlands Water Protection and Planning Council (Highlands Council) is a regional planning agency that works in partnership with municipalities and counties in the Highlands Region to encourage a comprehensive regional approach to implementing the 2004 Highlands Water Protection and Planning Act (the Highlands Act). The Highlands Act established the Highlands Council and charged it with the creation and adoption of a regional master plan to protect and enhance the natural resources within the New Jersey Highlands. The Highlands Regional Master Plan (RMP) was adopted by the Highlands Council on July 17, 2008 and became effective on September 8, 2008. The RMP (New Jersey Highlands Council RMP website) covers multiple topics and specifically addresses water supply.

PINELANDS COMMISSION

The New Jersey Pinelands Commission is an independent state agency whose mission is to "preserve, protect, and enhance the natural and cultural resources of the Pinelands National Reserve, and to encourage compatible economic and other human activities consistent with that purpose." To accomplish its mission, the Commission implements a comprehensive plan that guides land use, development and natural resource protection programs in the 938,000-acre Pinelands Area of southern New Jersey.

Additional information about the plan and its water supply elements can be found on the Comprehensive Management Plan page.

WATER RESOURCES OF CONCERN FOR DEFICIT MITIGATION AND AVOIDANCE

This section addresses regional resources where a potential or validated deficit has been identified. Some regional issues have already been addressed, some are being addressed by current studies, and others should be addressed through additional research and coordinated policy development. The resources of concern may involve surface water reservoir systems, unconfined groundwater and surface water supplies, confined aquifers, or a combination of these.

SURFACE WATER RESERVOIR SYSTEMS

The surface water supply reservoir systems' (see Chapter 2 and Appendix B) contractual obligations and water use are reviewed in accordance with N.J.A.C. 7:19 and N.J.A.C. 7:10, to ensure that they have not overcommitted or withdrawn more water than their safe yield will support. No reservoir systems in New Jersey face deficits, but some are expected to face additional demands due to population growth as population shifts throughout the coming years. The Raritan System of New Jersey Water Supply Authority has uncommitted safe yield for future needs (current average annual demand is 176 mgd of a total 241 mgd safe yield, as of early 2023), but it has the potential for interbasin transfers to support other systems. The Monmouth County reservoir systems (both publicly-owned and investor-owned) appear to have sufficient supplies for current demands (current average annual demand is 23.7 mgd of a total 30 mgd safe yield), but the reservoir systems in southern Monmouth County may face additional demands from northern Ocean County, especially for the Lakewood area that has been growing very quickly. It is important to note that demands on any one reservoir system can vary year-to-year. These demand changes can result when interconnected systems lose supply to contamination and choose to purchase water to meet their

A water release at Spruce Run Reservoir in Clinton, New Jersey. This reservoir is considered one of the first water supply facilities to be constructed and operated by the state.

own system demands. These shifts can be permanent or temporary and necessitate close monitoring to ensure demands do not exceed safe yield. It is also important to periodically review reservoir operations to ensure that the current operations will supply adequate water to meet current demands.

The reservoir systems that need and have received greatest attention are those of the Passaic, Hackensack and Raritan watersheds, in part because they support a large percentage of the state's population, and in part because they are highly interconnected. Importantly, when a drought occurs, it does not necessarily affect all reservoir systems equally; precipitation is not necessarily equal across the watersheds, and some reservoirs drop faster than others. At times, droughts have forced the transfer of supplies between different systems, which has cost and supply risk implications. To help understand the water supply issues, drought risks and potential climate change impacts, DEP has developed a regional model using the RiverWare platform. DEP routinely interacts with the various major surface water systems in the region (North Jersey District Water Supply Commission, Newark, Jersey City, Passaic Valley Water Commission and New Jersey American Water in the Passaic, and Veolia in the Hackensack) to monitor storage trends and demands, especially during dry periods. The model is currently being expanded to ultimately include the coastal north (i.e., Monmouth County) reservoir systems. In recent droughts, the issue of changes to finished water or drinking quality when source water is shifted has risen as an important issue that requires further assessment. Nevertheless, finished water interconnections and coordinated operations are critical tools to address water supply emergencies, droughts, and future demands.

CONFINED AQUIFERS

Several confined aquifers experienced excessive withdrawals and drawdowns due to historic allocations exceeding sustainable limits. The 1981 Water Supply Management Act provided the DEP with an important process to address these areas. The areas of critical water supply concern are defined in 58:1A Subchapter 7 and 7:19 Subchapter 8. In two cases, DEP formally declared Areas of Critical Water Supply Concern (commonly referred to as Critical Areas), where confined aquifer withdrawals were sharply restricted and alternative surface water supplies provided. Concerns about additional confined aquifers have resulted in aquifer models supporting planning, management and regulatory actions short of an Area of Critical Water Supply Concern designation. DEP and USGS cooperatively monitor and assess confined aquifer water levels through the Coastal Plain Synoptic Water Level program, ensuring that changes in aquifer levels are identified and management responses can be triggered by adverse trends. The most recent analysis used 2018-2019 data.

These areas are discussed in this section, with an overview of the major issues, actions taken prior to this Plan, and any necessary actions that are anticipated as a result of this Plan and ongoing activities. Additional confined aquifer analysis and data are available in recently published USGS report (Gordon et. al, 2021). Additional information is also available in Appendix C- Water Management Options: Confined Aquifers of the New Jersey Coastal Plain.

WATER SUPPLY CRITICAL AREA #1

Issue Overview: Water Supply Critical Area #1 or CA1 is centered on Monmouth County but includes large portions of northern Ocean and eastern Middlesex Counties (Whipple, 1987). The critical area was designated in 1985 to address saltwater intrusion potential in the Potomac-Raritan-Magothy (PRM) confined aquifers (specifically, the Englishtown/Middle PRM/Mt. Laurel/Upper PRM), caused by drawdown of potentiometric surface due to excessive withdrawals. Based on aquifer models and amendments to the Water Supply Management Act, withdrawals were fixed or reduced up to 50% of the respective systems water use in 1983 depending on aquifer and location, with alternative water supplies identified and developed. This resource has been addressed through Step 6 of the Regional Planning and Management Framework.

Water Supply Critical Areas are governed by 7:19 Subchapter 8 and CA1 boundaries are defined in 7:19 8.4(a), which states that "[t]he boundary of the depleted zone of the critical area corresponds to the average potentiometric contour 30 feet below mean sea level for each affected aquifer, as published in "Water Levels in Major Artesian Aquifers of the New Jersey Coastal Plain, 1983 U.S.G.S., WRI 86-4028." The threatened zone, consisting of a three-mile-wide margin area, surrounds the depleted zone of each aquifer."

Level of Certainty: Validated, based on detailed aquifer monitoring and modeling.

Level of Severity: Highly Stressed prior to initiation of management activities, now substantially reduced and managed.

Completed Planning and Management Activities: The USGS collaborated with DEP to develop an understanding of confined aquifer levels in the Coastal Plain aquifer system, which were then used to develop confined aquifer models for the affected area, providing the basis for reducing annual withdrawals. DEP identified alternative water sources to replace the lost confined aquifer supplies. The Manasquan Reservoir in southern Monmouth County was constructed and is operated by the New Jersey Water Supply Authority (NJWSA). A pipeline from Middlesex County transfers water treated and delivered by Middlesex Water Company from the NJWSA Raritan System to the northern portion of Critical Area #1.

Ongoing Planning and Management Activities: The models are updated periodically (see Spitz et al., 2007) and used to determine whether the reduced withdrawals are achieving the intended purpose. At this time, the models indicate that the management objectives have been achieved. The DEP works with the USGS to collect and analyze water levels on a five-year cycle for all coastal plain aquifers (which include those of Critical Area 1). To prevent worsening of conditions, the DEP is prohibited from granting new or increased diversions from the affected aquifers in both the threatened and depleted zones.

Potential Planning and Management Activities: Continued implementation of critical area procedures. No additional activities are required other than periodic assessment, review and enforcement of current requirements.

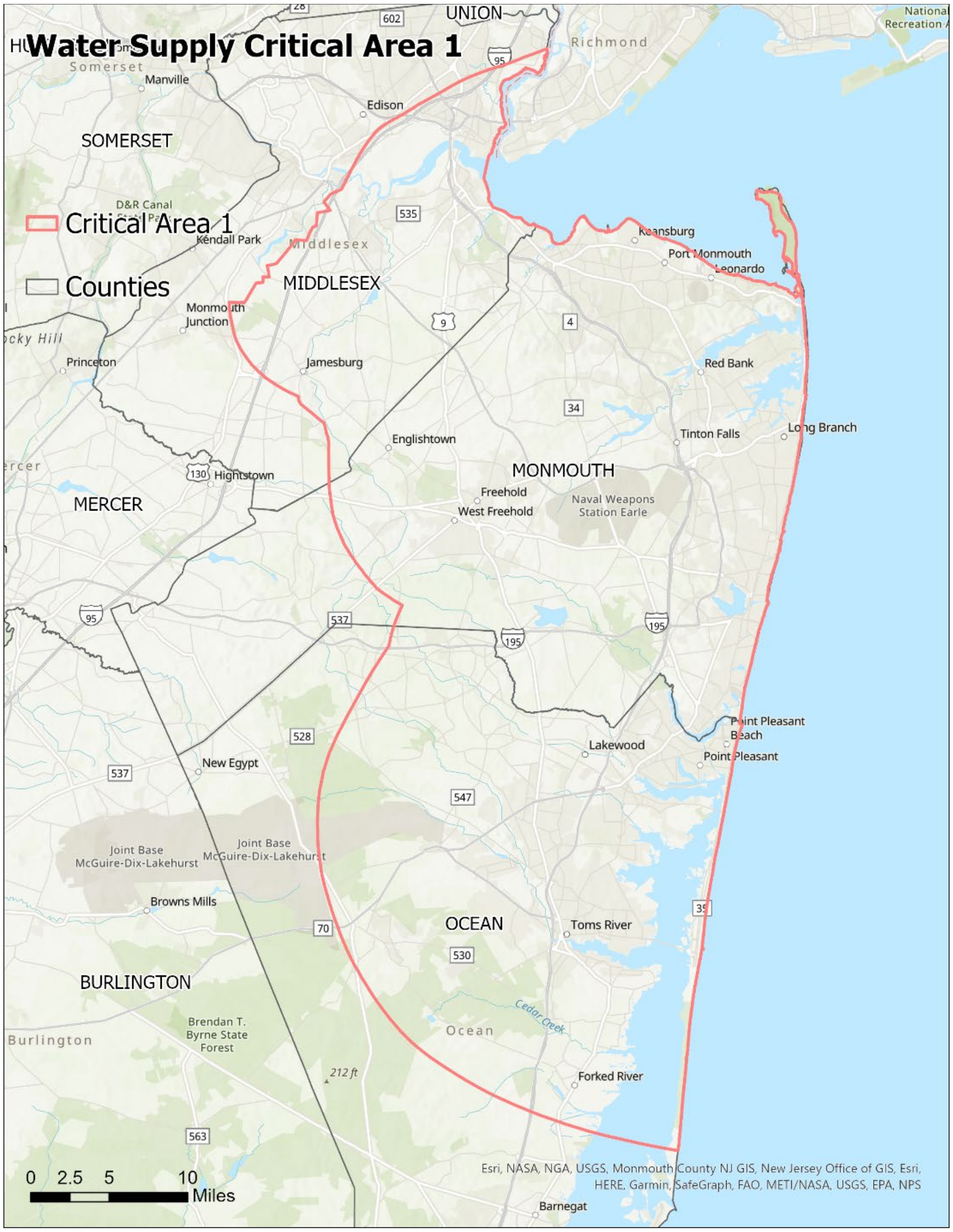


Figure 6.1 Composite boundary for Water Supply Critical Area 1 and surrounding counties.

WATER SUPPLY CRITICAL AREA #2

Issue Overview: Water Supply Critical Area #2 or CA2 is centered on Camden County but includes most of Burlington and Gloucester Counties and much of western Atlantic County (Spitz et al., 2008). The critical area was designated in 1993 to respond to saltwater intrusion potential in the Potomac-Raritan-Magothy (PRM) confined aquifers, especially along the Delaware River, caused by drawdown of potentiometric surface due to excessive withdrawals, as defined by a static water level contour equal to or lower than 30 feet below mean sea level (-30 ft msl). Based on aquifer models and amendments to the Water Supply Management Act, withdrawals were reduced by up to 35%, of the volume diverted in 1983, or the volume diverted in 1991, which ever volume is smaller with alternative water supplies identified and

provided. This resource has been addressed through Step 6 of the Regional Planning and Management Framework.

Water Supply Critical Areas are governed by 7:19 Subchapter 8 and CA2 boundaries are defined in 7:19 8.5(a), which states that “[t]he boundary of the depleted zone of the critical area corresponds to the average potentiometric contour 30 feet below mean sea level for each affected aquifer, as published in "Water Levels in Major Artesian Aquifers of the New Jersey Coastal Plain, 1983 U.S.G.S., WRI 86-4028." The threatened zone, consisting of a three-mile-wide margin area, surrounds the depleted zone of each aquifer.”

Level of Certainty: Validated, based on detailed aquifer monitoring and modeling.

Level of Severity: Highly Stressed prior to initiation of management activities, now substantially reduced and managed.

Completed Planning and Management Activities: The USGS collaborated with DEP to develop an understanding of confined aquifer levels in the Coastal Plain, which were then used to develop confined aquifer models for the affected area, which provided the basis for reducing annual withdrawals. DEP identified alternative water sources to replace the lost confined aquifer supplies. The primary alternative supply was a new intake and treatment plant on the Delaware River at Delran, owned and operated by the New Jersey American Water Company.

Ongoing Planning and Management Activities: The models are updated periodically (see Spitz and DePaul, 2008) and used to determine whether the reduced withdrawals are achieving the intended purpose. At this time, the models indicate that the management objectives have been achieved. As with Critical Area #1, DEP is prohibited from granting new or increased diversions from the affected PRM Aquifer System. However, water allocation credits may be transferred from the water allocation credit exchange to become part of a permittee’s base allocation. The credit exchange program is available to areas in the northern portion of the Rancocas Creek and is subject to DEP approval, but managed by the Burlington County Water Credit Exchange program (N.J.A.C. 7:19-8.5(d)).

Potential Planning and Management Activities: Continued implementation of critical area procedures. No additional activities are required other than periodic assessment, review and enforcement of current requirements.

Figure 6.2 Water Supply Critical Area 2 and surrounding counties.

WENONAH-MOUNT LAUREL AQUIFER

Issue Overview: DEP has identified this confined aquifer as showing declining static water levels. There are concerns that the aquifer may be experiencing withdrawals that exceed long-term sustainability. This aquifer is in the same geographic area as Water Supply Critical Area #2 (but affecting a different confined aquifer), raising the possibility that Wenonah-Mt. Laurel aquifer would be relied upon as an alternative water supply for those withdrawals that were reduced in the same area.

Level of Certainty: Validated Stress, based on aquifer monitoring and modeling.

Level of Severity: Moderate. The concern is sufficient to justify restrictions on new or increased water allocation permits, but not to a level required for designation of a water supply critical area or addition to the aquifers currently in Water Supply Critical Area #2.

Completed Planning and Management Activities: USGS cooperated with DEP on development of two studies regarding these aquifers, Navoy (1994) and Watt and Voronin (2005). The first study (Navoy, 1994) was developed to assess the potential impacts of additional withdrawals from the Wenonah-Mt. Laurel aquifer, in part due to withdrawal reductions in PRM in Water Supply Critical Area #2. This study indicated the potential for major reductions in potentiometric surfaces in the Camden and Burlington County portions of the aquifer due to additional withdrawals. The second study (Watt and Voronin, 2005) investigated the possible effects of using wells (specifically, inactive wells in Deptford Township) near the outcrop area of the Wenonah-Mt. Laurel aquifer; the issue was whether the increased withdrawal effects would be felt in the confined portion of the aquifer or in the unconfined portion, potentially harming wetlands and stream flows. Half of the modeled withdrawals would come from decreased stream flow (the unconfined aquifers), and a third from increased movement of water from the overlying Vincentown aquifer.

Ongoing Planning and Management Activities: DEP discourages new or increased annual confined ground water diversions from the Wenonah-Mt. Laurel aquifer and evaluates each request, taking into consideration availability of alternative supplies and localized conditions in the aquifer.

Potential Planning and Management Activities: The connection between the aquifer and the PRM in Water Supply Critical Area #2 provides a case for updating the 2005 model with new population and water demand projections to determine if additional steps are required.

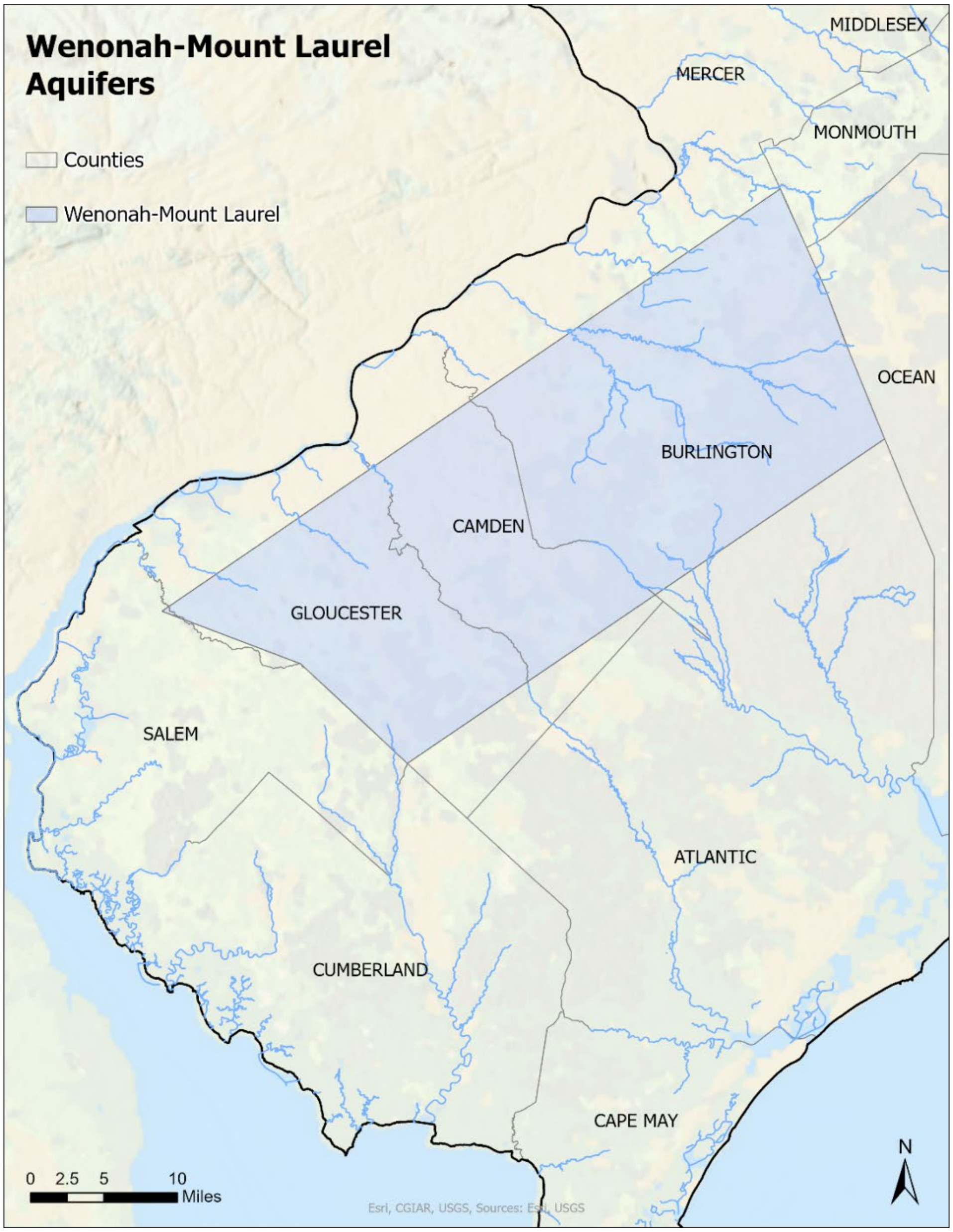


Figure 6.3 Wenonah-Mount Laurel aquifer and surrounding counties.

PINEY POINT AQUIFER

Issue Overview: DEP has observed declining water levels in the Piney Point aquifer in the Bridgeton area. Additionally in the Ocean County area the aquifer is at or near full allocation. There are concerns that the aquifer may be experiencing withdrawals that exceed long-term sustainability.

Level of Certainty: Validated Stress, based on aquifer monitoring and modeling.

Level of Severity: Moderate. The concern is sufficient to justify restrictions on new or increased water allocation permits, but not to a level required for designation of a water supply critical area.

Completed Planning and Management Activities: Several aquifer tests were reviewed by DEP staff to determine hydrogeologic boundaries and limitations which may be exacerbating the observed drawdown.

Ongoing Planning and Management Activities: Proposed new and increased allocations are reviewed to determine if they will increase aquifer drawdown or interfere with other permitted diversions.

Potential Planning and Management Activities: Development of a regional groundwater model should be considered to better characterize and quantify the impacts and to evaluate alternatives.

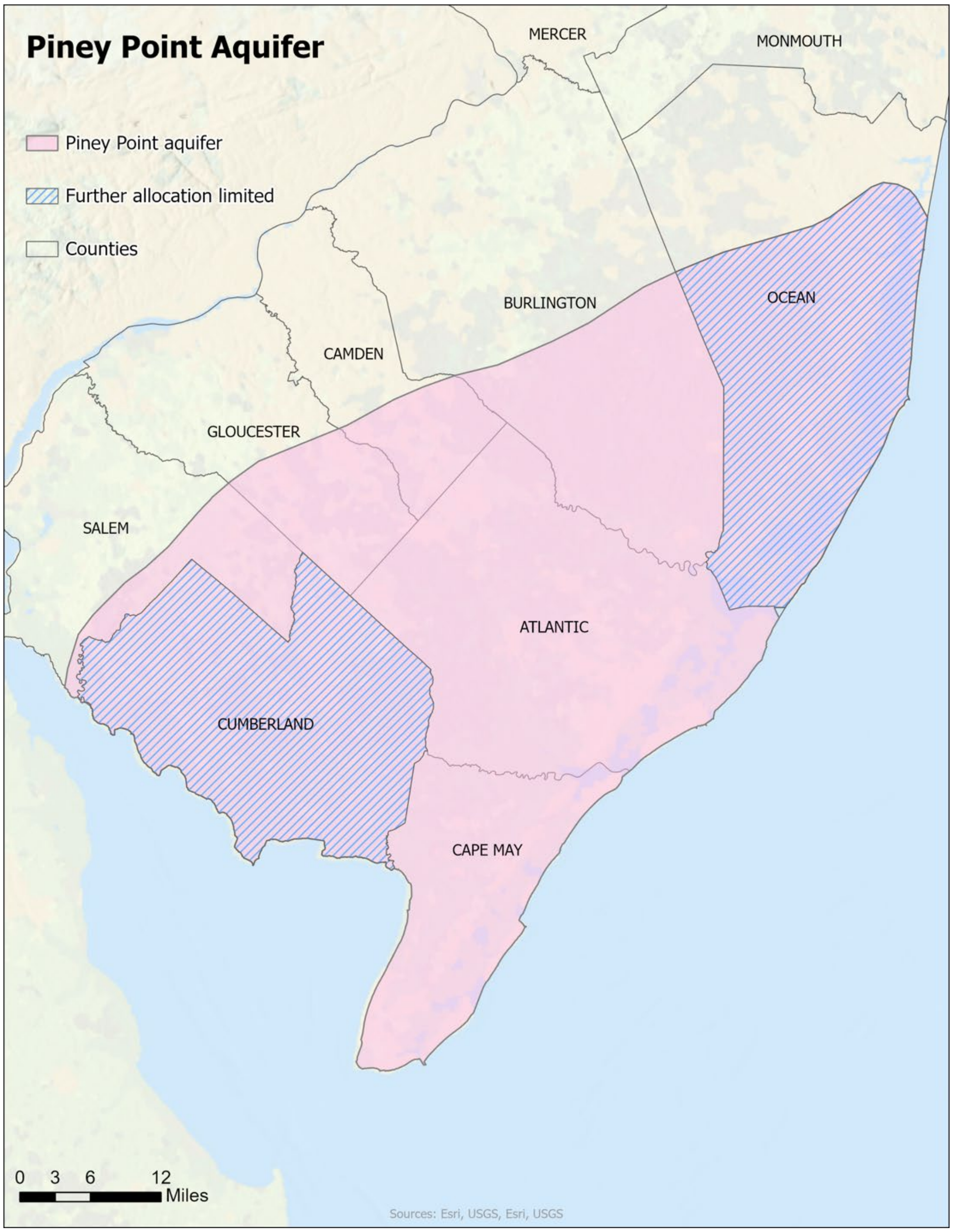


Figure 6.4 Piney Point aquifer and surrounding counties. Aquifer is at or near full allocation in hatched counties where the aquifer is present.

WMA 16: CAPE MAY STUDY AREA

Issue Overview: Saltwater intrusion occurred in multiple aquifers (e.g., Holly Beach water-bearing zone, estuarine sand aquifer, Cohansey aquifer, Rio Grande water-bearing zone, Atlantic City 800-foot sand) under the southern Cape May peninsula, resulting in loss of freshwater public water supply wells in several municipalities including Cape May City (Cohansey aquifer wells replaced with desalination using locally brackish groundwater from wells completed in the Atlantic City 800-foot sand) and a concern about further saltwater intrusion in the area. The New Jersey Legislature appropriated funds (P.L. 2001, Chapter 165) to DEP for a detailed study of the issue including ecological impacts from groundwater withdrawals in addition to saltwater intrusion. This resource has been addressed to Step 6 of the Regional Planning and Management Framework.

Level of Certainty: Validated, based on aquifer monitoring and modeling.

Level of Severity: Moderately Stressed, based on confirmed saltwater intrusion that forced a shift to desalination in Cape May City, mixing of well water in other municipalities, and potential loss of domestic wells in southwestern Lower Township MUA (LTMUA).

Completed Planning and Management Activities: USGS has collaborated with DEP to complete several studies of the affected aquifers in southern Cape May County, including aquifer modeling. Other recent studies (Carleton, 2021; Lacombe, 1996; Lacombe and Carlton, 2002; Lacombe et al., 2009; Spitz, 1996; Spitz, 1998) have provided significant insight into the hydrogeologic setting of Cape May and feasible alternatives. The DEP is currently conducting a comprehensive review of these options in conjunction with localized monitoring efforts. The goal is a unified water allocation permitting strategy for water supply to Cape May while addressing the saltwater intrusion threats to production wells. Most recent modeling simulations were done to see the effects of full allocation pumping effects compared to baseline scenarios results (Carleton, 2021). These studies have allowed DEP to construct and implement a framework for water allocation permitting decisions and resulted in specific actions such as new interconnections and the movement of wells away from salty water towards the ‘spine’ of Cape May County.

Ongoing Planning and Management Activities: DEP will not approve new or increased annual allocations that would accelerate saltwater intrusion, reduce stream flow, or harm natural resources. Only sustainable water supply alternatives based on USGS recommendations are considered when necessary to meet the current and future water supply needs of Cape May County. Options to relocate water withdrawals away from areas of concern would require collaboration among multiple water supply entities, with resulting cost implications.

While Cape May County's year-round population is expected to remain close to the same through 2050, much of the water demand is driven by tourism during the summer season. Sea level rise is expected to increase the submerged areas of the county, placing some wells at risk of tidal inundation, as discussed in Chapter 3.

Upgrading emergency interconnection infrastructure to enhance two-way transmission points throughout the region is ongoing and further encouraged. This allows for more flexibility and resilience for the region.

Potential Planning and Management Activities: The aquifer model needs to be updated using recent aquifer monitoring data, water withdrawals, sea level rise, population trends and tourism activity to determine whether the scenarios of the USGS 2009 and Addendum 2020 study (Carleton, G.B., 2021) are still valid in the context of sea level rise. While most confined aquifers are deemed safe from sea level rise impacts for the foreseeable future (see Chapter 3), that cannot be said for confined aquifers already experiencing saltwater intrusion in stressed areas. Unconfined and leaky confined aquifers are also at risk from sea-level rise induced saltwater intrusion. Based on the updated analysis, DEP will collaborate with local interests to determine whether and how further actions should be taken to mitigate or avoid further saltwater intrusion.

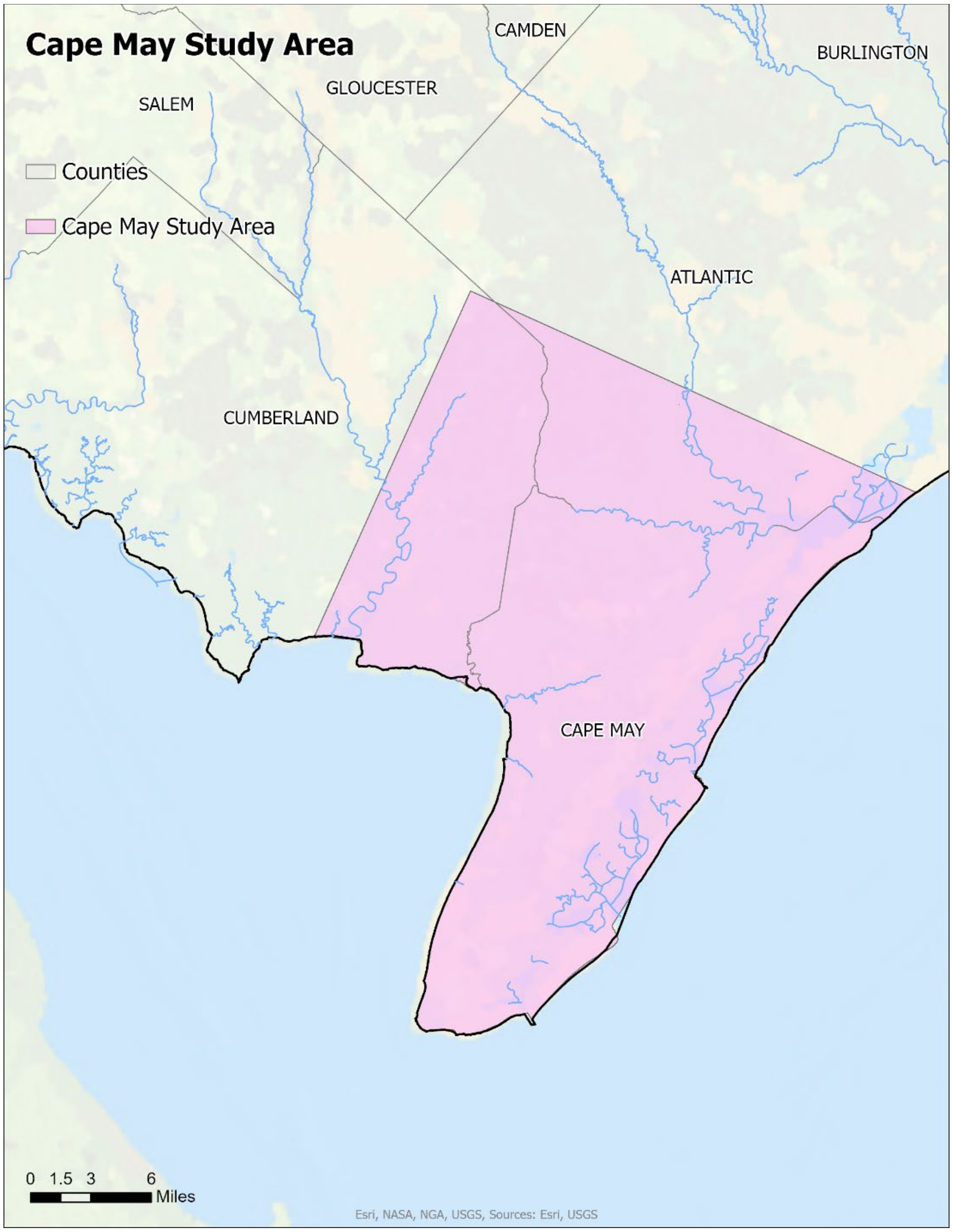


Figure 6.5 Cape May Study Area and surrounding counties.

WMA 17: GLOUCESTER/SALEM STUDY AREA CONFINED AQUIFERS

Issue Overview: DEP has identified that increased PRM confined aquifers withdrawals south of the existing Water Supply Critical Area 2 boundary could potentially force expansion of the Critical Area, as defined by a static water level contour equal to or lower than 30 feet below mean sea level (-30 ft msl). Expansion of the Critical Area, using existing authorities, could trigger withdrawal limitations and substitution with other water supplies.

Level of Certainty: Validated Stress, based on aquifer monitoring and modeling.

Level of Severity: Moderate, as some saltwater intrusion impacts have been experienced but not at a wide scale; the concerns are validated enough to require monitoring and management.

Completed Planning and Management Activities: USGS has cooperated with DEP in the development of a 2011 report to assess the effects of allocated and projected withdrawals on PRM aquifer levels in the project area (Charles et al., 2011). A regional evaluation of WMA 17, including Salem, Cumberland and part of Gloucester counties (Step 3 of the Framework for Regional Water Supply Planning and Management) was prepared as part of the 2023-2028 Plan (see Appendix J), providing context for further planning. While the Salem County population is projected to decline by roughly 10% between 2020 and 2050, Gloucester County's population is expected to grow by more than 10%, with seven times the population gain as Salem's projected loss. Sea level rise is a significant issue in Salem County, including the City of Salem.

Ongoing Planning and Management Activities: In Salem and Gloucester Counties south of Critical Area 2 there are concerns that new or increased diversions from the PRM Aquifer System could expand the -30 static water level contour that could expand the critical area. At this time, DEP has determined that proposed new or increased allocations must be evaluated taking into consideration availability of alternative supplies and localized conditions in the aquifer.

Potential Planning and Management Activities: The 2011 USGS study projected demands out to the year 2025. New population and water demand projections could be coupled with updated aquifer status data and sea level rise projections in the tidal Delaware River, to re-evaluate the results of the 2011 model and determine if additional steps are required.

Figure 6.6 Gloucester/Salem Study Area and surrounding counties.

UNCONFINED AQUIFERS AND RELATED STREAMS

As with confined aquifers, there are unconfined aquifers where historic water allocations, prior to more modern understanding of aquifer sustainable yields, have resulted in either excessive withdrawals or full allocation of the aquifers. In other areas, initial information indicates a potential concern based on statewide models. More detailed information and, at times, resource-specific modeling will be needed to verify the concerns. These areas are discussed in this section, with an overview of the major issues, actions taken prior to this Plan, and any necessary actions that are anticipated as a result of this Plan and ongoing activities.

WMA06: BURIED VALLEY AQUIFER SYSTEM OF MORRIS AND ESSEX COUNTIES

Issue Overview: A large and somewhat interconnected system of buried valley aquifers exists in the Central Passaic River area of western Essex County and eastern Morris County. Buried valleys are pre-glacial valleys that were filled with sediments, sands and gravels during the period of glacial retreat. In several cases, the buried valleys have sand and gravel deposits that are highly productive for wells. They underly a number of rivers, such as the Passaic, Whippany and Rockaway, but also cross watershed lines.

These aquifers have been used since the late 1800s, and with the advent of major suburbanization in the region, water levels in the aquifers were dropping. Unlike confined aquifers, these buried valley aquifers are either unconfined or semi-confined. This allows water to move between the buried valley aquifers and either overlying surface waters or adjacent bedrock groundwater units. Their unconfined nature also allowed for the movement of pollutants into the aquifers, which frequently occurred due to industrial development, landfills, leaking gasoline station tanks and other sources (Van Abs, 1986).

Level of Certainty: Validated, based on aquifer monitoring and modeling.

Level of Severity: Moderate. The concern is sufficient to justify restrictions on new or increased water allocation permits, but not to a level required designation of a water supply critical area.

Completed Planning and Management Activities: DEP developed an aquifer model in the 1980s to better understand the aquifer systems and test the effects of additional withdrawals (Hoffman, 1989). The study concluded that several buried valley aquifers were already over pumped as of 1985, others were overallocated but not yet over pumped, and some had remaining capacity beyond current pumping or allocations. As a result of this model and other analyses, DEP determined that no new or additional water allocations should be permitted. Partially as a result of these restrictions and additional water needs, three water systems (Parsippany-Troy Hills Township, Southeast Morris County Municipal Utility Authority and New Jersey American Water) augmented their aquifer withdrawals (and in the case of New Jersey American Water, pumped storage reservoirs) with additional surface water supplies drawn from the Jersey City system (Parsippany) and a pipeline from the Passaic Valley Water Commission facility in Little Falls (SMCMUA and New Jersey American Water).

In addition, a regional evaluation (Step 3 of the Framework for Regional Water Supply Planning and Management) was prepared as part of this Plan (see Appendix H), providing context for further planning. Morris and Essex Counties anticipate low to moderate population increases. Water withdrawals have declined since the 1990s and for most PCWS that trend is expected to continue, reducing aquifer stresses.

Ongoing Planning and Management Activities: In addition to the specific regulatory actions and infrastructure improvements, DEP has generally been protecting these and other aquifers from additional recharge losses through the NJAC 7:8 Stormwater Management Rules that are applicable statewide. These rules, most recently amended in 2023, seek to maintain existing groundwater recharge and minimize pollutants in stormwater runoff among other goals. Specifically, no new or increased allocations from the Buried Valley Aquifer System in northeast New Jersey (Ramapo/Passaic/Par-Troy areas) are permitted as these areas have been fully allocated since the 1990s.

Potential Planning and Management Activities: The 1989 groundwater model is among the oldest in New Jersey. Given the importance of these buried valley aquifers to the region, and despite the potential for declining withdrawal trends, an update to the model may be appropriate to address the history of aquifer pollution, major changes in development patterns since the 1980s, the potential for population growth, and the fact that much of the Morris County area is now within the Highlands Region.

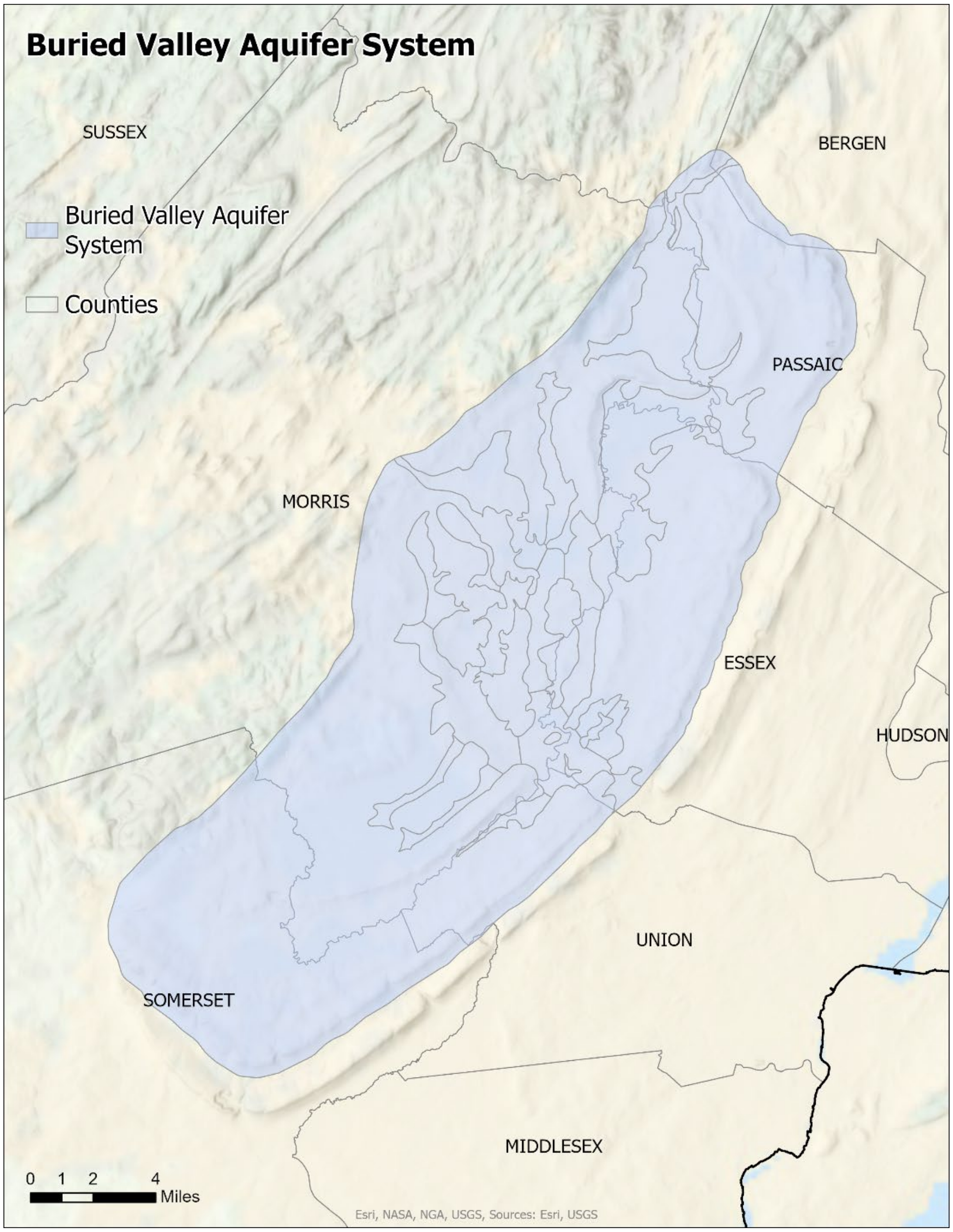


Figure 6.7 Buried Valley Aquifer System and surrounding counties.

WMA11: LOCKATONG CREEK SURFICIAL AQUIFERS

Issue Overview: Lockatong Creek is part of WMA 11-Central Delaware Tributaries, and it provides part of the flow to the Delaware & Raritan Canal, a major water supply to central New Jersey that is owned and

operated by the New Jersey Water Supply Authority (NJWSA), a state agency. DEP has determined that the watershed is at or approaching full allocation, based on existing water allocation permits and agricultural use certifications. The watersheds largely have shallow soils over Newark basin aquifer's limited groundwater storage potential. Despite the mostly rural nature of the watersheds, the streams have very high flows during storms and limited base flow during dry periods. It is the limited potential for groundwater infiltration and storage that makes the watersheds sensitive to withdrawals, which have been increasing with development. The high storm flows also contribute to erosion that damages water quality in the Delaware & Raritan Canal.

Level of Certainty: Potential Stress

Level of Severity: Moderate. The concern is sufficient to justify restrictions on new or increased water allocation permits, but not to a level required for designation of a water supply critical area. Limited population growth is forecast through 2050 from a small existing population base in this rural area.

Completed Planning and Management Activities: The NJWSA developed a watershed management study for the Lockatong Creek and its neighboring watershed, the Wickecheoke Creek (Kratzer et al., 2009). This project identified the initial concerns regarding water withdrawals. The Lockatong and Wickecheoke comprise HUC11 02040105200; the LFM analysis shows some remaining capacity based on recent peak annual withdrawals, but total water allocations significantly exceed the available water.

Ongoing Planning and Management Activities: DEP has determined that new or increased water allocations will be evaluated on a case-by-case basis.

Potential Planning and Management Activities: This area has been identified using the LFM analysis and NJWSA study. Therefore, the initial steps from the Framework for Regional Water Supply Planning and Management are appropriate for this area. They include data verification and model reanalysis (steps 1 and 2). If the same limitations are still identified then regional evaluation and enhanced monitoring, modeling and analysis would be warranted (steps 3 and 4) and planning, management, and regulatory responses might be warranted (Step 5).

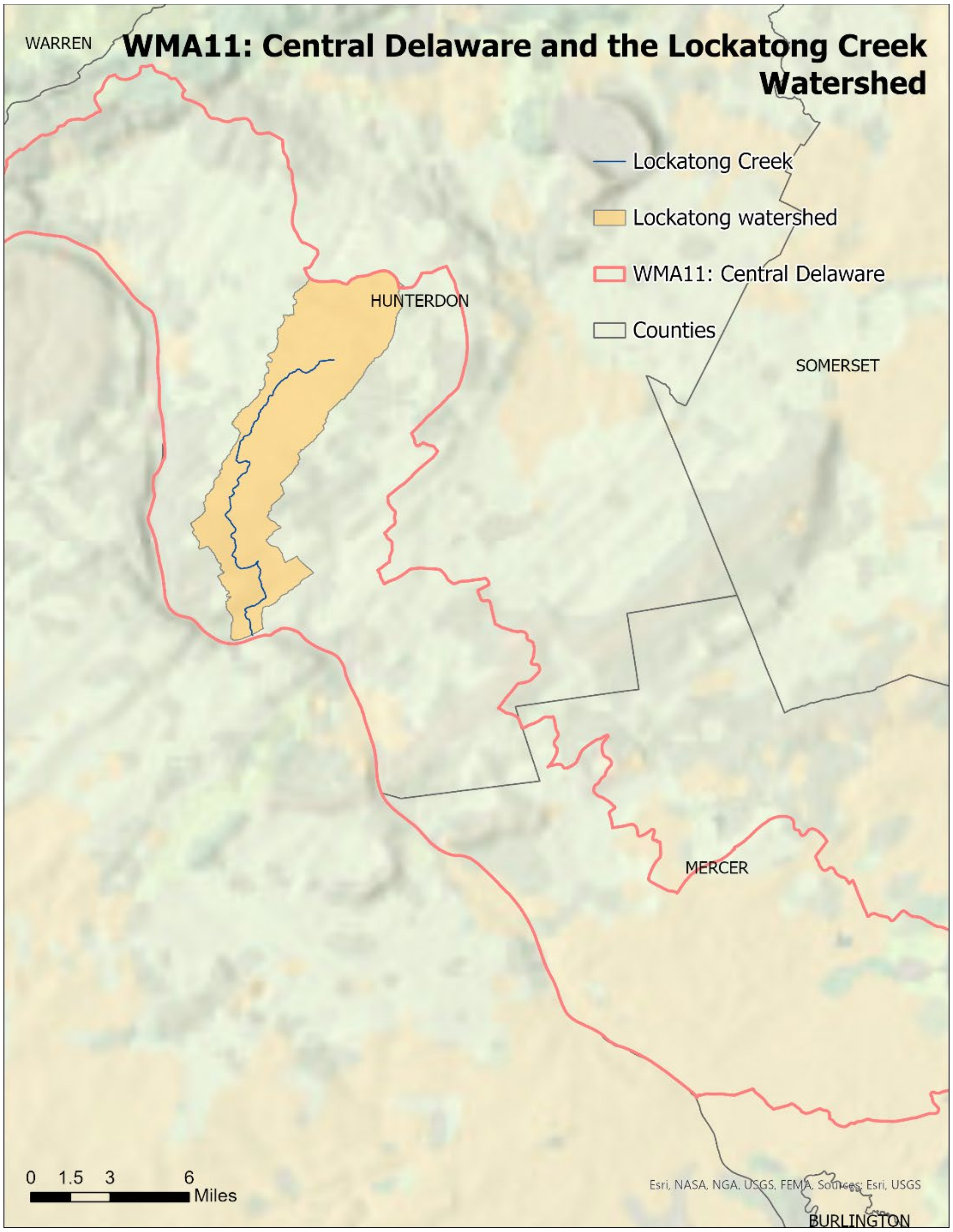


Figure 6.8 WMA 11 and the Lockatong Creek watershed.

WMA13: BARNEGAT BAY WATERSHEDS SURFICIAL AQUIFERS

Issue Overview: Barnegat Bay and the adjacent barrier islands are critical components of New Jersey's tourism industry; flows from tributaries to the Bay are critical to maintaining the ecological integrity of the estuarine Bay (Barnegat Bay Partnership, 2021). Through a combination of monitoring and models, DEP has identified static water level decline in the unconfined aquifers near pumping centers in this region, indicating potential excess use of the unconfined aquifer. In addition, the LFM analysis indicates that four HUC11 areas in WMA13 have calculated consumptive and depletive water demands that exceed water availability (Metedeconk River (02040301040), Kettle Creek / Barnegat Bay North (02040301050), Toms River (above Oak Ridge Parkway) (02040301060), and Toms River (below Oak Ridge Parkway)

(02040301080)). All the more densely populated areas within the region are connected to sewage treatment facilities that discharge to the ocean, and most of these areas are dependent on aquifer withdrawals. Population growth through 2050 is forecast to significantly outpace statewide growth, adding to these stresses.

Level of Certainty: Validated Stress (USGS model) and potential deficit (LFM method)

Level of Severity: Minor with some subregions moderate.

Completed Planning and Management Activities: As a result of planning efforts leading to the 1996 Plan, USGS and DEP cooperated on a study (Nicholson and Watt, 1997) to evaluate potential effects of unconfined aquifer withdrawals on stream flows in the Toms River, Metedeconk River and Kettle Creek watersheds, in the northern portions of WMA13. The study determined that aquifer withdrawals through the 1980s had created static water level declines near the well fields, reducing stream flows by up to 11%, and withdrawals at full allocation levels would reduce stream flows even more, up to 15% in Kettle Creek. Seasonal reductions would be even higher due to the close connection between the groundwater and stream flows and the much higher summer withdrawals to address tourism and outdoor water uses.

In addition, a regional evaluation (Step 3 of the Framework for Regional Water Supply Planning and Management) was prepared as part of the 2023-2028 Plan (see Appendix I). Ocean County is expected to grow, adding potential water demands that may be offset to some extent by ongoing water use efficiency trends. The region includes Lakewood Township, a very rapidly growing municipality.

Ongoing Planning and Management Activities: DEP has determined that new or increased water allocations in the Kettle Creek watershed (a subwatershed to WMA13) must address impacts to base flow. This could include long-term aquifer testing and surface water level and streamflow monitoring, or the development of ground or surface water models calibrated to the watershed.

Potential Planning and Management Activities: The USGS modeling was developed in the 1990s using aquifer withdrawals from the 1980s. An update of the model is appropriate to reflect more recent (and likely better documented) withdrawals, recent static water levels, and updated demand projections.

Figure 6.9 Barnegat Bay WMA, watersheds with allocation restrictions, and HUC11s within.

WMA17: MAURICE/SALEM/COHANSEY WATERSHEDS SURFICIAL AQUIFERS

Issue Overview: WMA17 includes several rivers that drain the southern portion of the Pinelands and other lands along the Delaware Bay. The region has extensive agricultural areas but also forested lands and various small to medium urban centers that developed either as town centers for regional agricultural or manufacturing (e.g., glass making) endeavors. The Delaware Bay shore area is very flat and highly susceptible to sea level rise as seen in the Climate Change portion of this Plan. The Maurice River and several of its tributaries (Menantico and Muskee Creeks and the Manumuskin River) are part of the National Wild & Scenic River System. While Salem County's population is projected to decline, Cumberland County's population is forecast to increase, though slower than the statewide average.

Groundwater modeling has identified issues regarding the impacts of groundwater and surface water withdrawals within the WMA17 watersheds on river flows. Using the Low Flow Margin evaluations for the 2024 Plan, 13 HUC11s in WMA17 are identified as stressed. HUC11s 02040206080 (Cohansey River (above Sunset Lake)), 02040206150 (Muddy Run), and 02040206030 (Salem River (above 39d40m14s dam)/Salem Canal) have the third, seventh, and tenth highest results in the State, respectively, in terms of calculated demands exceeding total available water. The dominant largest consumptive/depletive peak loss in the stressed HUC11s is agricultural irrigation, which was reported in nine of 13 stressed HUC11s. The stress in WMA17 is a known deficit area, with previous research identifying stress in the following areas:

- Gloucester-Salem;
- Salem River Watershed;
- Upper Maurice Drainage Basin; and
- Water Supply Critical Area 2.

Level of Certainty: Validated Stress

Level of Severity: Moderate. The concern is sufficient to justify restrictions on new or increased water allocation permits, but not to a level required for designation of a water supply critical area.

Completed Planning and Management Activities: As a result of planning efforts leading to the 1996 Plan, USGS and DEP cooperated on studies in the Salem River (Johnson and Charles, 1997) and Upper Maurice River watersheds (Cauller and Carleton, 2006). The Salem River study area is roughly equivalent to Salem County (with part of southwestern Gloucester County) and includes the river, nearby watersheds, and both the unconfined and confined aquifers of the region. The study assessed base stream flow, which represented 64 to 75 percent of total annual flow, depending on the stream. The study developed a general water budget based on 1990 data, estimating that consumptive uses comprised 1% of annual precipitation; recharge was equivalent to 29% of precipitation. However, the study did not include development of a full aquifer model.

The Upper Maurice River study compared modeled pre-development groundwater conditions with mid-1990s conditions. Withdrawals were estimated to have caused major reductions in stream water base flows (i.e., dry weather flows) by 25 to roughly 60 percent, depending on the watershed involved. Using future withdrawal projections to 2040 indicated that at least one stream could have no base flow in summer conditions and others would suffer losses beyond 1990s conditions, though higher recharge changes would have a significant positive effect on these findings. At full allocation withdrawals, the base flow reductions would be worse than under projected demands, with several streams losing all or nearly all base flow during summer conditions. Wells in the unconfined aquifers have a roughly 1:1 effect on stream base flows.

In addition, a regional evaluation (Step 3 of the Framework for Regional Water Supply Planning and Management) was prepared as part of the 2024 Plan (see Appendix H), to provide context for further planning. While the Salem County population is projected to decline by roughly 10% between 2020 and 2050, Gloucester County's population is expected to grow by more than 10%, with seven times the

population gain as Salem's projected loss. Sea level rise is a significant issue in Salem County, including the City of Salem.

Ongoing Planning and Management Activities: DEP has restricted new or increased surface water allocations from the Salem River and the related unconfined aquifer, as the basin is fully allocated upstream of the Salem Canal. Likewise, new or increased Kirkwood-Cohansey Aquifer System or surface water consumptive uses upstream of Union Lake in the Upper Maurice River watershed are restricted. See Figure 6.10 for a map of these subregions.

Potential Planning and Management Activities: The two USGS studies are from 1997 and 2005 for the Salem and Maurice River watersheds, respectively, reflecting water withdrawal data that is from 20 or more years ago. In the intervening years, withdrawal patterns may have changed significantly, and it has become clear that climate change (including sea level rise) is an increasingly important issue in the region because of the potential for warmer temperatures to increase agricultural withdrawals. Also, the low elevations along the Delaware Bay pose a threat to the nearby groundwater resources and to local farmlands. In addition, recent research has shown that reported agricultural withdrawals may be significantly higher than actual withdrawals due to the method used (i.e., pump capacity multiplied by hours of operation, rather than metered flows).

Therefore, improved withdrawals data for both areas, updated analyses of the Maurice River watershed model and development of a similar model for the Salem River study area are appropriate at this time. The analyses will benefit from use of the regional evaluation found in Appendix J.

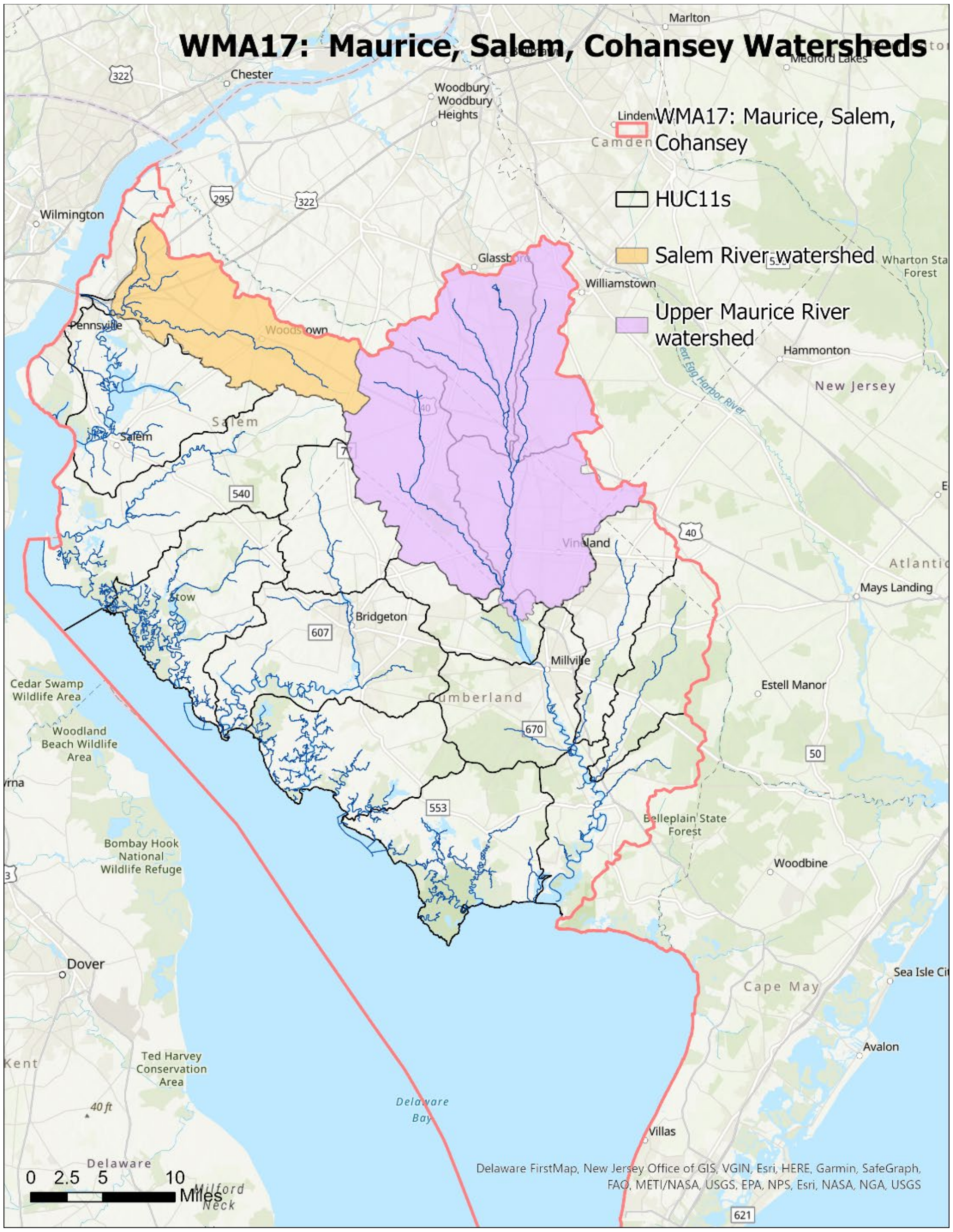


Figure 6.10 Maurice/Salem/Cohansey WMA, watersheds with allocation restrictions, and HUC11s within.

WMA20: BLACKS CREEK WATERSHED

Issue Overview: Surface water in Blacks Creek (HUC11 02040201080) above Chesterfield-Georgetown Road show signs of overallocation and difficulty meeting permitted surface water diversions under low flow conditions. LFM method shows the HUC 11 to be limited at full allocation.

Level of Certainty: Likely Stress based on potential deficit (LFM method)

Level of Severity: Moderately severe

Completed and Ongoing Planning and Management Activities: New surface water allocations in this area are reviewed on a case-by-case basis.

Potential Planning and Management Activities: Data validation and additional monitoring are needed to improve the hydrology and hydrogeology of the sub-watershed.

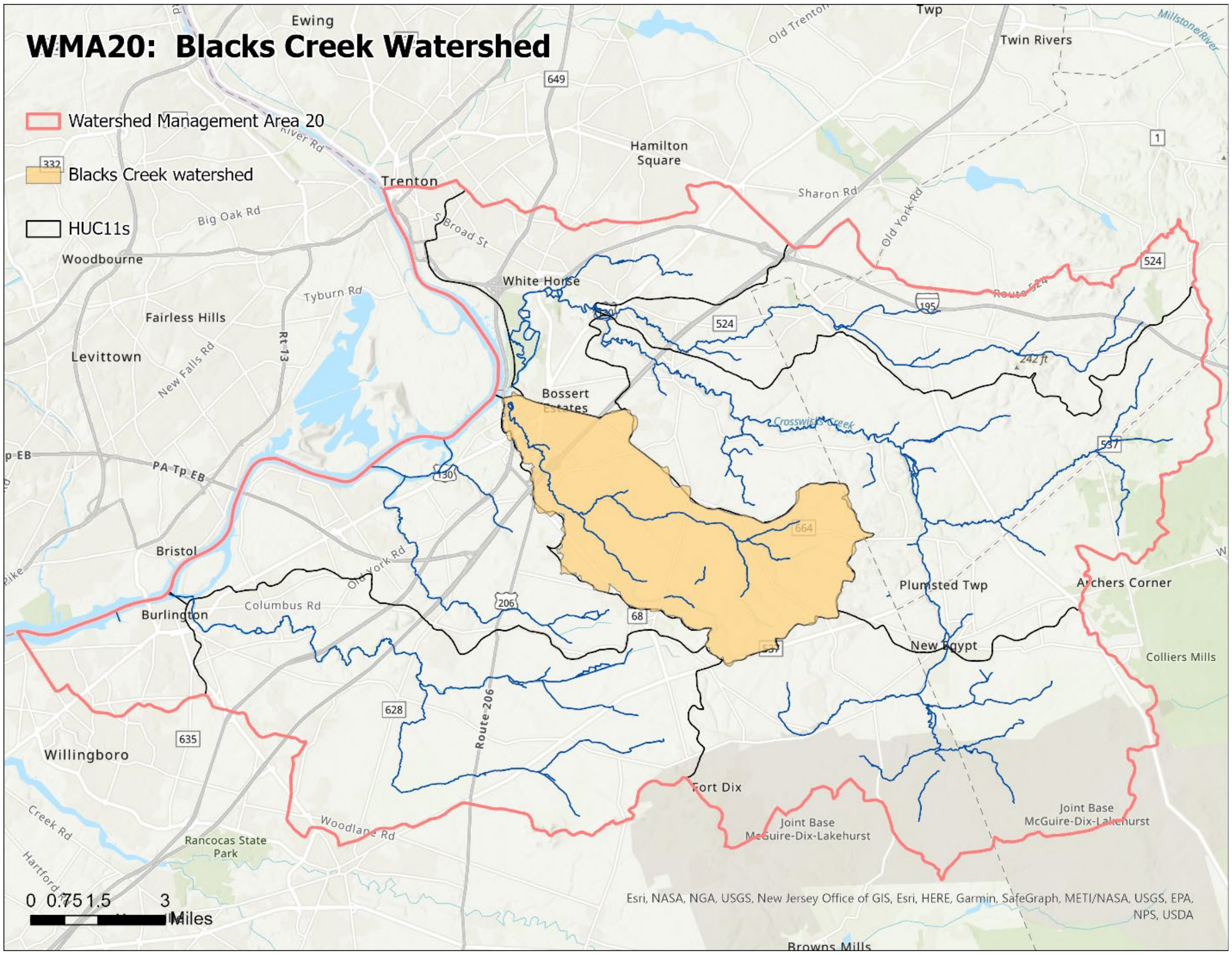


Figure 6.11 WMA 20 and the Blacks Creek watershed with allocation restrictions.

COMBINED CONFINED AND UNCONFINED AQUIFERS

One region has been identified as a potential future concern for excess use of interconnected confined and unconfined aquifers, based on potential future demands.

WMA 14 AND 15: MULLICA AND GREAT EGG HARBOR STUDY AREA AQUIFERS

Issue Overview: These two Watershed Management Areas are predominantly in the Pinelands Region, discharge to estuarine bays, and have major unconfined aquifers (primarily the Kirkwood-Cohansey) and underlying confined aquifers that require assessment as somewhat interconnected resources. Pinelands stream, wetlands, and bog ecosystems are highly dependent on the Kirkwood-Cohansey aquifer system. Some of the HUC11 drainage areas are showing indications of water stresses. In addition, significant agricultural production areas exist within the region, which are highly dependent on groundwater for

irrigation purposes on a seasonal basis; reported withdrawals may not be accurate due to methodology issues with withdrawals for agricultural uses. Growth in the Pinelands Region is restricted in some areas and encouraged in other areas within these watersheds. Much of the region is within the Preservation Area, Forest Area or Agricultural Production Area. Atlantic County is forecast to experience population growth at less than half the statewide average.

Level of Certainty: Validated Stress

Level of Severity: Moderate for the study area

Completed Planning and Management Activities: USGS and DEP have cooperated on a modeling study in the two areas, for the unconfined and confined aquifers (Pope et al., 2012).[2] Demands are largest from the Kirkwood-Cohansey aquifer system, but the confined aquifers are important water resources as well for potable supplies. In addition, the Kirkwood-Cohansey aquifer is the major source of recharge to the lower confined aquifers (primarily the Atlantic City 800-foot sand). The model was used to evaluate current, projected and full allocation scenarios. The 2050 demand scenario would have demands roughly 50% higher than the 1998-2006 average, primarily due to potable supply demand increases, while the full allocation scenario would be twice the 1998-2006 average, with the addition primarily due to agricultural water use certifications. The 1998-2006 average scenario indicated that deficits (excessive base flow depletion) occurred in half the subbasins, nine for the 2050 Demand scenario and 11 for the Full Allocation scenario.

Ongoing Planning and Management Activities: DEP has determined that new or increased allocations from confined and unconfined aquifers must be evaluated taking into consideration alternate available water supplies for the intended use and potential impacts on the resource and other users of the resource. Seasonal conjunctive use (confined and unconfined aquifers) and reuse of treated wastewater could be evaluated to lessen groundwater demands. In late 2022, the Pinelands Commission proposed amendments to CMP regulations (N.J.A.C. 7:50-6.86 (a-e)) regarding water management within the Pinelands, which may limit Pinelands water withdrawals further.

Potential Recommended New Planning and Management Activities: Several steps are recommended for this region. The importance of agricultural withdrawals (both current and at full allocation) indicates that additional effort should be made to better quantify actual withdrawals and to project future needs. Potable water withdrawals are important currently and for the year 2050; an update to demand forecasts should be tested in the model to assess stresses for that year. In addition, if the Pinelands CMP rules are adopted, the implications of those rules for future water demands should be assessed.

Figure 6.12 Mullica and Great Egg Harbor Study Area.

OTHER REGIONS NEEDING ADDITIONAL REVIEW

In addition to the specific regions discussed above there are several more generic situations which also require additional review when the DEP makes water supply allocation or agricultural certification decisions. These areas and the additional review are listed below.

- Classification Exception Area (CEA): new or increased allocation to be evaluated on a case-by-case basis. The CEA (Polygon) coverage was developed to provide information regarding the spatial extent of groundwater contamination within designated Classification Exception Areas

(CEAs) and Well Restriction Areas (WRAs). The potential for proposed withdrawals to interfere with CEAs must be evaluated and avoided.

- **Delaware and Raritan Canal**: new or modified surface water diversions from the Delaware and Raritan Canal must apply to the NJWSA. Interstate water rights and negotiations determine water availability via the canal during times various phases of drought, prescribed by the agreements and operations in the FFMP 2017 Operation Plan, Table 1. Evaluation of current yield and existing allocations are necessary to ensure future water availability for new and current users.
- **Emergent Wetland**: new or increased allocation to be evaluated on a case-by-case basis. The Emergent data set depicts critical area maps for emergent dependent species which are generated by selecting specific land-use classes from the DEP's LULC data set. This data set is a product of the Landscape Project, a pro-active, ecosystem-level approach to the long-term protection of imperiled and priority species and their important habitats in New Jersey.
- **Forested Wetland**: new or increased allocation to be evaluated on a case-by-case basis. The NJDEP Forest Critical Habitat data set depicts critical area maps for forest dependent species which are generated by selecting specific land-use classes from the DEP's LULC data set. This data set is a product of the Landscape Project, a pro-active, ecosystem-level approach to the long-term protection of imperiled and priority species and their important habitats in New Jersey.
- **Raritan Basin**: new or increased allocation upstream of the Bound Brook gage must contract with the New Jersey Water Supply Authority for the consumptive portion of their annual allocation or increased annual allocation respectively. The Raritan River Basin includes 1,100 square miles of land that ultimately drain to the Raritan Bay through the Raritan River. The Basin includes large areas of urban, agricultural and forested land, along with significant areas of wetlands. Historic and recent land uses have resulted in the loss or degradation of significant watershed resources, including wetlands, riparian areas (stream corridors), and ecosystems in urban and agricultural areas. Ground water recharge is decreasing due to increased impervious cover such as roads, parking lots and buildings, which in turn reduces the flow in small streams during dry periods. For more information regarding the Raritan Basin and operational data can be found at New Jersey Water Supply Authority - The Raritan Basin System.
- **Upstream of Reservoir or Potable Water Intake**: the DEP has concerns with new or increased consumptive or depletive water uses upstream of surface water supply reservoir systems. The safe yield of these systems is based upon observed flows during the system's drought of record. Any new water loss that would occur during a repeat of the drought of record streamflow could reduce the system's safe yield. Requests are reviewed on a case-by-case basis to estimate the impact to safe yield and appropriate response. In some cases, the response may be to require the new diversion to contract with the impacted system for the amount of the safe yield reduction.

STREAM LOW FLOW MARGIN REGIONAL FOCUS AREAS

Appendix A- Stream Low Flow Margin (LFM) Method Results summarizes results for all of New Jersey's HUC11 drainage areas and are organized by Watershed Management Area (WMA). Each characterization includes a summary of the region's water sources as well as a description of categorical water usage

during the peak water use year recorded between 2011 and 2020. The data and methodologies used in the development of these summaries are provided in Chapters 2 and 4 and referenced resources/documentation. Six principal water use categories may be represented within a WMA:

- Agriculture;
- Commerce/Industry/Mining;
- Domestic (individual, private wells);
- Non-agricultural Irrigation;
- Potable Supply; and
- Power Generation.

The New Jersey Water Tracking Model (NJWaTr, see Chapter 2) is used to identify water imports and exports. The LFM methodology (see Chapter 4) to quantify water availability, in combination with the NJWaTr results, is used to ensure the sustainability of surface and unconfined groundwater sources. It is important to emphasize that the quantification of net water availability provides a tool to help frame planning and regulatory decisions within HUC11s, but it cannot be used in place of site-specific assessments for individual water allocation permit decisions.

Results of the LFM analysis indicate two distinct regions of New Jersey where clusters of HUC11s share the same primary water use and have consumptive and depletive demands that exceed total water availability (limited HUC11s). These clusters cover large portions of a handful of WMAs and are focus areas for future DEP action. Specific areas of interest are outlined in the figures below. In the northeastern portion of New Jersey, a clear cluster of limited HUC11s can be observed in the Lower Raritan-Passaic region where the primary water use is potable. In the southwestern region of New Jersey, large portions of Cumberland and Salem counties are seen to have primary water use related to agriculture. Some of these areas, especially WMA 17 in Salem and Cumberland counties, were discussed above (e.g., WMA 6 Buried Valley Aquifer System, WMA 17 Maurice/Salem/Cohansey Watersheds), they are grouped here as having common issues at a larger regional level.

NORTHEASTERN REGION: LOWER RARITAN-PASSAIC

Issue Overview: This region includes all of WMA 9, most of WMA 7 and the southern (non-Highlands) portion of WMA 6. It includes some of the most complex of New Jersey’s water supply infrastructure and surface water management capabilities. The region also serves many New Jersey residents. It is served by several water purveyors that operate large surface water systems located outside of the identified region that are interrelated both with respect to meeting the water demands of their customer base as well as passing flow requirements that are ecologically protective. However, this region also has concentrated areas of groundwater withdrawals in suburban areas that historically relied on groundwater prior to creation of the reservoir systems, or because the reservoirs primarily served more urban areas.

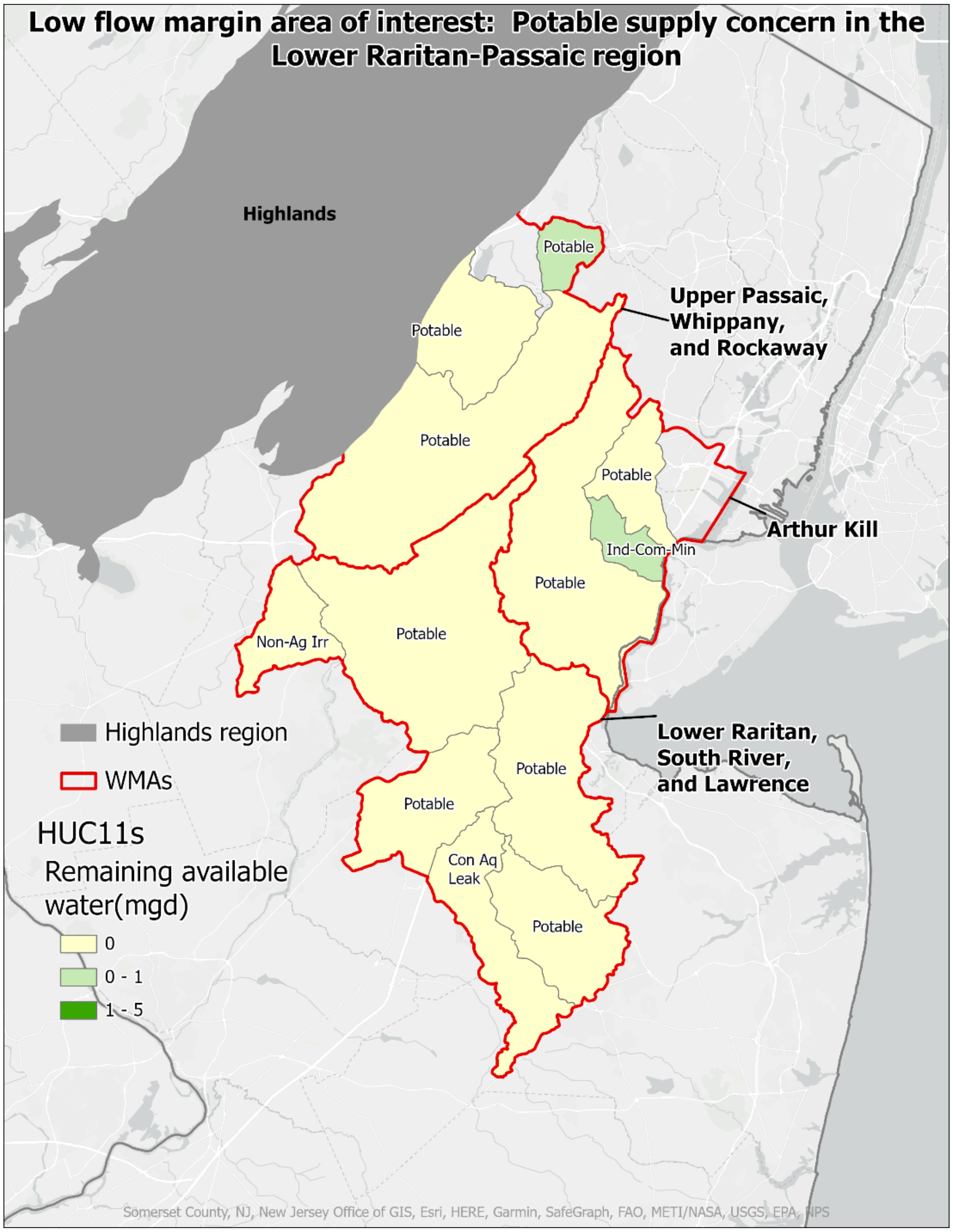


Figure 6.13 Shows limited HUC 11s (yellow) in the northeastern region of interest. HUC 11s are labeled with the use group that contributes most to depletive/consumptive loss.

Level of Certainty: Potential Stress (LFM)

Level of Severity: Moderate to High, depending on the HUC11 assessed.

Completed Planning and Management Activities: As discussed previously, modeling for the Buried Valley Aquifer System of the Central Passaic River Basin in WMA6 (Hoffman, 1989) provided the basis for restrictions on new or increased water allocations from those aquifers. Other portions of the region have not been the focus of detailed aquifer analysis or modeling.

Ongoing Planning and Management Activities: This area is newly identified as a whole, and therefore there are no completed activities. Subregions have been previously identified and are covered in other sections of this chapter.

Potential Planning and Management Activities: To refine the analysis of water availability, it would be appropriate for further research in this region to incorporate more robust future predictions of streamflow regimes into existing hydraulic modeling of the region, based on the best available climate change science. Reanalysis at the HUC12 level should be considered. Preliminary research by DEP indicates that in some instances there may be increases in average and dry-period streamflow due to increasing precipitation, potentially associated with climate change. Updating water system modeling to include these potential flow regimes will enable DEP to better understand whether this region is likely to remain limited in its availability as noted by the LFM. Additionally, the discharge data from the NJPDES program for treatment plants operating in the region should be further verified to ensure that key discharges are being adequately reflected in the LFM calculations (i.e., as discharges either to freshwater or saline waters), leading to greater confidence in the modeled LFM results. Finally, a deeper examination of the region's resiliency can be assessed through examination of supply contracts between suppliers.

SOUTHWESTERN REGION: WMA 17 - CUMBERLAND AND SALEM COUNTIES

Issue Overview: This region includes the bulk of WMA 17 which spans the counties of Cumberland and Salem, as discussed above. The predominant water use in the limited HUCs seen in this region is for agriculture. Specifically, regarding the agricultural demands, there has been uncertainty surrounding the data on agricultural withdrawals for some time in New Jersey, as noted in both the 1996 and 2017 Plans. Agricultural irrigation withdrawals are often estimated as opposed to being measured with totalizing flow meters, which are not required for agricultural withdrawals in New Jersey. Recent work has shown that when estimated, reported agricultural withdrawals often exceed that which was withdrawn, particularly by higher volume users. As agricultural consumptive water uses drive LFM results in this region, it is critical that improved withdrawal data be developed.

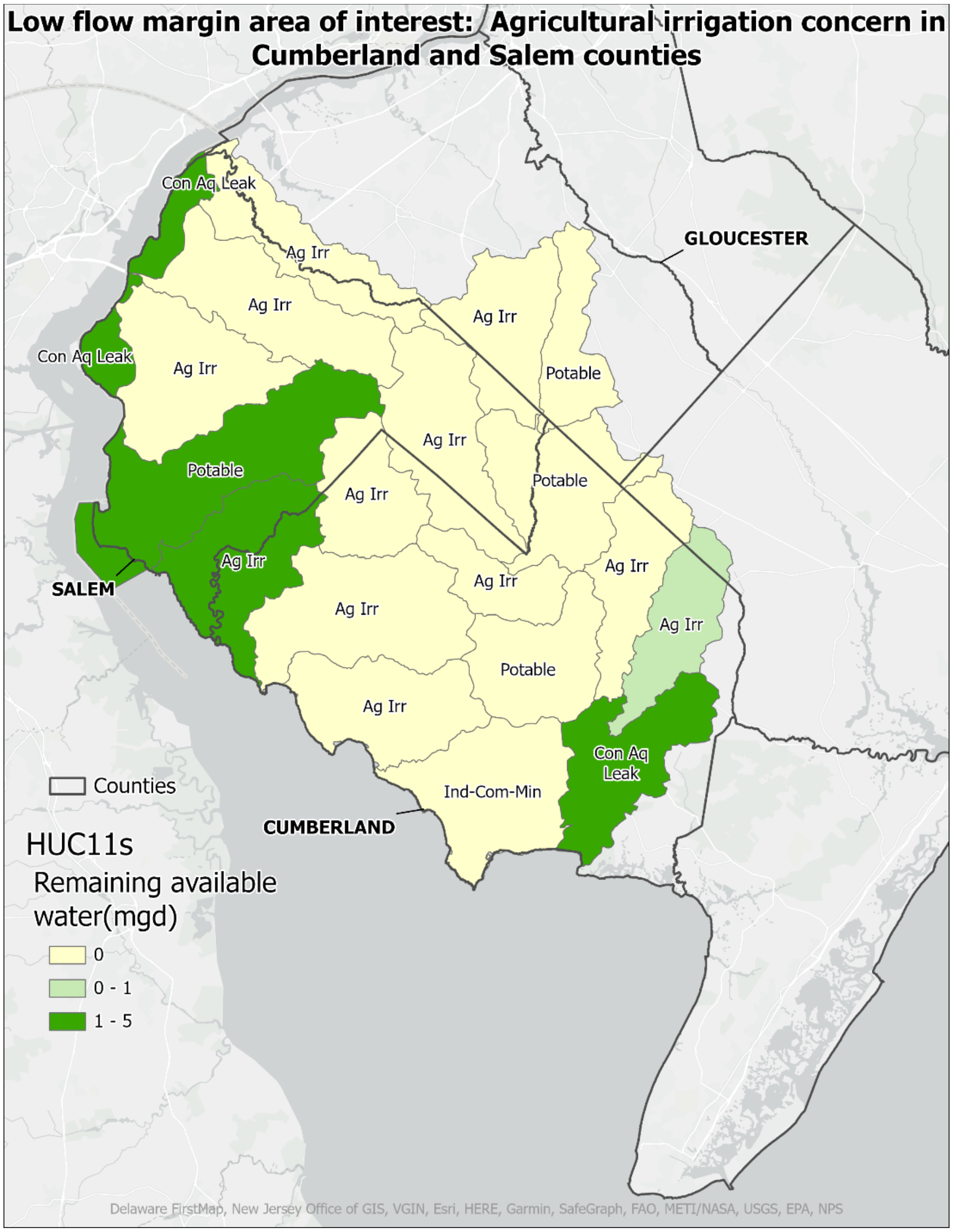


Figure 6.14 Shows limited HUC 11s (yellow) in the southwestern region of interest. HUC 11s are labeled with the use group that contributes most to depletive/consumptive loss.

Level of Certainty: Potential Stress (LFM)

Level of Severity: Moderate to High, depending on the HUC11 assessed.

Completed Planning and Management Activities: See WMA 17 section above.

Ongoing Planning and Management Activities: See WMA 17 section above.

Potential Planning and Management Activities: Greater work in data verification should be undertaken to improve confidence in the LFM results. This should include careful examination of all water uses in the

region with a particular focus on improving confidence in the data related to agricultural water use. Agricultural certifications and registrations (permits) should be analyzed to better understand where totalizing flow meters are already being used so that DEP can focus on sub watersheds where the bulk of the water use reporting by agriculture relies on estimation. Reanalysis at the HUC12 level should be considered. Further QAQC can be performed on the data in this area and DEP should consider funding programs to place totalizing flow meters on withdrawals by larger volume agricultural users as a way of validating the LFM results and providing a more accurate accounting of agricultural water use in this region. As part of this process, the research could determine whether statistical relationships could be used to modify estimated withdrawals where metered data are not available.

ADDITIONAL HUC11S SHOWING A LFM DEFICIT

Issue Overview: In addition to the major regional areas outlined above, there are some HUC11's outside these regions where LFM results indicate potential limitations. These HUCs may or may not fall into areas where there are known water supply issues. In many cases they will be entirely their own case studies and potentially require different planning and management solutions. However, in general they will all require first data validation of the LFM results followed by model reanalysis.

Level of Certainty: Potential Stress

Level of Severity: Minor to moderate depending on local water use data

Completed and Ongoing Planning and Management Activities: DEP should review each HUC on a case-by-case basis to determine next steps. The overall LFM methodology may need to be revised first prior to identification of specific management options.

Potential Planning and Management Activities: Data validation and then model reanalysis are required as first steps so that NJDPE can determine if these areas are truly in deficit. Once completed DEP can move on to more enhanced monitoring or planning and management responses where necessary.

OPTIONS FOR REGIONAL WATER DEFICIT MITIGATION

Once a water resource is confirmed as having deficits, defined as either current or realistically projected withdrawals that exceed available water, a variety of actions are available that can mitigate or eliminate deficits. The following options comprise a "toolkit" that may be useful in specific regions. It is not expected that all approaches will be relevant to all resources in deficit. Many of these approaches are drawn from the statewide approaches discussed in Appendix L, but in this case could be implemented more extensively within specific regions, focused on specific water resources.

- **Protection of Water Resources**: A major factor in mitigation of deficits is to ensure that the existing water resources are protected and maintained, so that loss of water availability does not exacerbate deficits caused by demands. One approach is to engage in more intensive efforts to protect water quality and quantity, and in some cases to improve recharge to groundwater through green stormwater infrastructure and aquifer recharge.

- Water Loss Reduction: Water losses from public community water systems represent a withdrawal from water resources that is not used for any purpose. In many cases, the leakage from the PCWS will not return to the source water. Therefore, where water losses are abnormally high in deficit areas, reduction of withdrawals can be achieved through reduction of real water losses. PCWS which fail to mitigate water losses as identified in their Water Loss Audit, would be subject to the remedial measures identified pursuant to the DEP's rule proposal codifying the WQAA. PCWS which lack capacity to address the water loss are recommended to solicit technical assistance from the DEP, or other technical assistance providers, or consider regionalization-style approaches to share resources with neighboring systems.
- Demand Reduction: Water uses that are inefficient represent an unnecessary demand against resources. Improvements in water use efficiency often represent a cost-effective method of reducing withdrawals. The greater the deficit, the higher the benefit of demand reductions. Demand reductions can come from both indoor and outdoor water uses and from all types of land uses. The priority water demand categories and land uses for attention will change from region to region, based on which uses are major factors in creating the confirmed deficits.
- Alternative Water Supplies: The provision of alternative water supplies may or may not be feasible in specific regions, but it should be considered where and to the extent reduction of water losses and demands will not be sufficient to eliminate water deficits. The alternatives should focus on using the lowest quality water acceptable for the intended use. Solutions could include the shifting of demands from high-quality potable water to untreated water for non-potable water needs, interconnections and bulk purchases of treated or raw water from neighboring systems, or beneficial reuse of treated wastewater (RWBR). Use of RWBR should only occur where it will not harm stream flows that support aquatic ecosystems and other water supplies. Other possibilities include stormwater capture and storage and aquifer recharge via treated captured/stored stormwater or treated wastewater, also known as Managed Aquifer Recovery (MAR), where applicable and where water quality remains appropriate.
- New Water Supplies: The option of developing a new water supply is the last major approach. In many parts of the state, the potential for new supplies will be limited by the same factors that resulted in the deficits, such as limited groundwater resources in a region that has no potential for surface water development. In other areas, surface water resources are fully developed as are the groundwater resources in the same area. However, there are some resources that could be developed after appropriate analysis.

SUMMARY

A critical goal of statewide water supply planning is to determine specific areas where existing or potential future withdrawals do or may exceed available natural and constructed water supplies, especially during dry periods. In this chapter, a water supply planning and management framework is provided to examine different regions with confirmed or potential water supply deficits. This six-stage framework ((1) Data Verification; (2) Model Reanalysis; (3) Regional Evaluation; (4) Enhance Monitoring; Modeling, and Analysis; (5) Planning, Management, and Regulatory Responses; and (6) Progress

Evaluation) is designed to be used in conjunction with the provided matrix that classifies the risks associated with water availability issues by considering stress certainty and stress severity.

The six-stage framework provides several benefits for increasing understanding of the risk associated with regional water supply issues. First, it can provide the opportunity to classify and prioritize more serious water issues, such as those designated as low certainty, high severity, or high certainty, high severity. In addition, efforts already taken to address regional water supply issues can be tracked using the framework to determine if water supply deficits have been avoided, mitigated, or eliminated. Furthermore, this framework can be implemented in coordination with other special regional initiatives that are already in place, such as those in the Delaware River Basin and the Highlands Region, where intensive planning and management efforts occur regardless of the presence of water availability constraints.

Belhaven Lake located in the New Jersey Pinelands.

This chapter also identifies several regional resources identified as having either a potential or validated water supply deficit. While some regional issues have already been addressed (Water Supply Critical Areas 1 and 2), some are being addressed in current studies (such as the regional evaluations conducted on WMA13's Barnegat Bay watersheds and WMA17's Maurice, Salem, and Cohansey watersheds – See Appendix I and J for more information). New areas of concern were also identified, such as the northeastern region's Lower Raritan – Passaic region, along with research needs to further evaluate several regional resources.

Once it has been determined that a water resource has deficits, a "toolkit" of actions is available to mitigate or eliminate deficits. Policy development should be pursued and may include consideration of strategies that can reduce water demand and water loss, provide further water resource protection, and/or explore the use of alternative and new water supplies. Planning efforts should include early engagement with agencies, organizations, and representative individuals to ensure key interests understand the water supply issue(s) and can effectively assist in the development of response strategies.

Two specific areas DEP intends to target related to regional planning for deficit mitigation and avoidance include:

- further evaluation and assessment of potential and validated regions of water supply deficit concern (especially newly identified areas) through more localized study and analysis; and

- continued coordination and engagement within DEPs and with regional initiatives, such as those in the Pinelands and Highlands, in the development of planning efforts and policy to address water supply deficit issues.

CHAPTER 7: MANAGING UNCERTAINTY: DROUGHT, RESILIENCE AND SUSTAINABILITY

TABLE OF CONTENTS

OVERVIEW

Precipitation varies across New Jersey -- from year to year, month to month, and even within a single rain event. On average, the State’s hilly northwestern region is wetter (roughly totaling up to 50 inches per

year) than the coastal plain to the south and east (as low as 39 inches per year) (Figure 7.1). However, average annual precipitation masks wide variations in precipitation events that occur throughout a given year. This precipitation variability, coupled with concentrated population centers, can produce wide fluctuations in water availability and demands. Many of New Jersey's reservoirs are relatively small and many users rely on unconfined aquifers, making them sensitive to annual or seasonal drought conditions, not just multi-year droughts. Over the past six decades, New Jersey has experienced several episodes of drought emergencies that resulted in water shortages of varying degrees, the most notable of which occurred in the mid-1960's, the early-to-mid 1980's, and again in 2001-02. Each drought emergency provided policy makers and water system operators lessons on how to better manage droughts or improve overall water supplies to increase overall water supply resilience. In some cases, drought emergencies paved the way for major legislation, as in the case of the Water Supply Management Act, and the construction of new reservoirs and pump stations, as was the case for the Wanaque South Project.

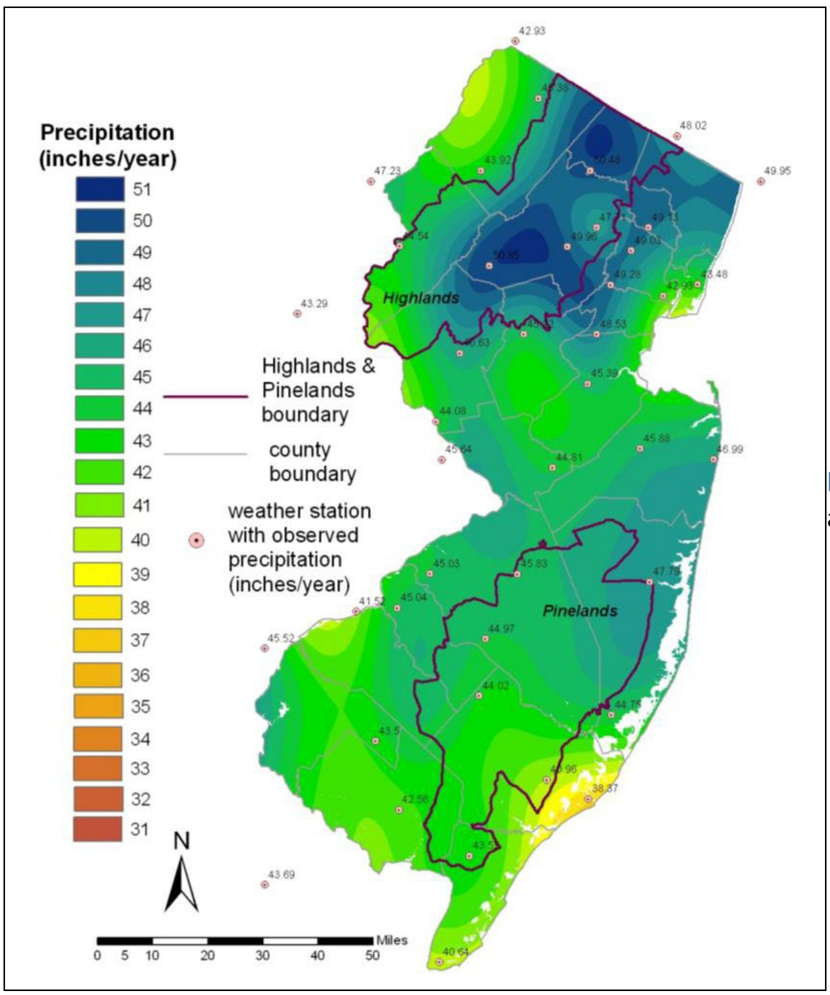


Figure 7.1 New Jersey annual average precipitation.

It is important to note that New Jersey also experiences potential water shortages during relatively short periods of dry weather that technically may not qualify as "official" water supply droughts according to

state managers. Such periods, while exhibiting some of the characteristics of a drought in terms of the relative scarcity of rainfall and/or above-average temperatures, might best be characterized as *demand-driven events* marked by high temperatures, significantly increased water demands and rapidly depleted surface water and groundwater reserves. This is exacerbated when the high-demand season begins with system reservoir storage below peak capacity. These demand-driven events occurred in 1995, 2005, 2006, 2010, 2017 and 2022 necessitating enhanced scrutiny and action by the DEP to ensure adequate water supplies were maintained.

The recurrence of these episodes is even more notable since they occurred during New Jersey's wettest period on record, based on annual precipitation.[1] In general, declines in total and per capita water use have been observed over the past two decades. However, steadily increasing water consumption for potable use, agricultural needs, and non-agricultural irrigation presents challenges to meeting essential water needs, especially in hot, dry summers. The developing statewide trend of more and more fresh water -- much of it highly treated drinking water-- being used to irrigate lawns and landscapes quickly strips water reserves during demand-driven water shortages. A shift in potable water demand was noted anecdotally during the COVID-19 summers of 2020 and 2021 when many residents invested in home landscaping and, where possible, worked from home, which resulted in many households using more water compared to the historical trends. Data from this time period is still being evaluated and while it does appear that some systems saw an increase in total demand, the results are mixed. This situation was further complicated by DEP's adoption of rules concerning per-and polyfluoroalkyl substances (PFAS) in June of 2020 which caused some purveyors to turn off or switch sources or purchase water from a larger neighboring utility with excess capacity due to detections of PFAS in certain water supplies.

As discussed in detail in Chapter 3, climate change impacts to water availability are a major concern, among other issues. At this time and based on the initial analyses conducted for this Plan, it appears that average groundwater availability has been increasing in many but not all areas, and projections indicate that in most future climate scenarios this trend will continue. The same is true for reservoir supplies. The forecasting of precipitation at time steps more granular than rough annual averages is not possible with current climate change models, but many researchers have suggested that variability between dry and wet periods may become more extreme. While droughts of short duration are expected to increase in frequency, the implications for drought management are not entirely clear. This has led to more frequent use of the term 'flash drought'. The National Oceanic and Atmospheric Administration (NOAA) defines flash drought as rapid onset or intensification of drought set in motion by lower-than-normal rates of precipitation, accompanied by abnormally high temperatures, winds, and radiation (NOAA 2023). While it is debatable as to whether New Jersey has experienced flash droughts in recent years, there has frequently been a juxtaposition between intense hot and dry periods that begin to concern water supply managers which are then punctuated by large precipitation events. Therefore, DEP is committed to ongoing research, model development, planning, monitoring, and event management to help better understand the likelihood of drought, both short-term, demand driven and multi-year, in the larger

[1] Since 1970, state-wide-average annual precipitation has increased about 3 inches. Average annual rainfall for the period 1895-1970 was 44.2. For the period 1971-2022 average precipitation is 47.5 (Monthly Climate Tables, NJ State Climatologist).

context of climate change. This will help the DEP identify approaches to preserve the water supply of the State and help ensure an adequate supply into the future.

Besides drought, other forms of uncertainty (bulleted below) also exist and must be addressed by DEP, water utilities and others. All these issues raise concerns, but also opportunities, with respect to environmental justice issues.

- The financial sustainability of water supply systems, as affected by the rising costs of energy, labor, materials, and capital projects contrast with declining per capita and total water sales.
- Resilience of water supply systems or the ability of each system to maintain operations and recover from external shocks such as weather events or cybersecurity failures.
- Redundance of water supply systems or the ability of each system to maintain operations and recover from internal shocks such as major infrastructure failures.
- The implications of sea level rise for the viability of water supply service areas in coastal locations.
- Potential changes in land use patterns which have the capacity to shift water supply needs in ways not easily forecast.

MANAGING WITHIN UNCERTAINTY

All water supply planning involves models, and all models are simplifications of reality. There can be no perfect knowledge of current and past conditions and there can be no perfect knowledge of the future. Therefore, uncertainty is inherent in water supply planning, and plans must acknowledge these uncertainties and develop ways of assessing future actions that incorporate uncertainty, usually through the use of scenarios that test a range of possible futures. It is important to note that uncertainty is fundamentally different from error. The term "margin of error" is misleading and should properly be seen as a "margin of uncertainty". Errors can be corrected, but uncertainty can only be mitigated or incorporated in planning and management.

The states of California, Florida, Georgia, Massachusetts, North Carolina, Texas, Virginia, and Washington are all large states with robust water planning programs. These states address uncertainty within their water supply plans in several ways. Many used modeling approaches that responded to uncertainties through the use of incremental modeling (e.g., demand planning for a horizon year that is routinely updated, projections in five-year increments), use of conservative assumptions (e.g., safe yield models based on severe precipitation shortages), use of regional models to augment statewide modeling, and incorporation of climate change sub-models. Several states used multiple projections based on differing model assumptions (e.g., varying population projections, drought versus average demands, future demand patterns by sector, and land development projection models).

States differed in their presentation of uncertainties within their statewide plans, ranging from limited statements to highly detailed appendices or modeling reports. Some noted the limitations of trend-based population projections and the potential effects of price elasticity. Several noted the complexity of water modeling, including water system interactions, land use change implications, data limitations, modeled versus observed flows, and the use of a margin of safety. The difficulty of downscaling global climate

models for state and sub-state precipitation projections was a frequent issue; some employed multiple scenarios or simulations to overcome these limitations in the modeling approach.

The states responded to these uncertainties by incorporating various research agendas and long-term planning approaches. No state incorporated all these approaches, but these ideas were common across many states. Key approaches include:

- development of regional studies, enhanced monitoring, updated statistics and modeling approaches, and collaborative research to better understand specific issues so that statewide results are improved;
- research on the use of multiple metrics within modeling, such as incorporating both water availability and water quality concerns within the modeling process;
- incorporation of multiple approaches to climate change, such as the use of central tendency models plus observed conditions;
- peer review to ensure appropriate "state of practice" in the planning process;
- establishing priorities among policy options, such as focusing on obvious beneficial steps first, or the use of multiple distinct approaches; and
- adaptive planning, using routine updates to models and plans that result in improvements based on improved data, related models (e.g., climate change), and concepts.

New Jersey's statewide water supply planning process already includes many of these approaches, specifically the use of regional studies, adaptive and iterative planning, identification of implementation priorities, and peer review of technical studies. General review of the Plan is also accomplished through the Water Supply Advisory Council. DEP's recent work regarding climate change science and adaptation will provide a more robust basis for water supply planning in future iterations of this Plan, as will improved interaction between water supply and water quality models and planning.

REDUCING UNCERTAINTY

Managing water supplies and water utilities requires dealing with uncertainty that is inherent in any effort to anticipate the future. No approach is perfect, and no innovation is possible to achieve perfection or total certainty. The primary approach that the state's water managers can take to address this uncertainty is to continuously monitor, assess, reevaluate, and revise and update the Plan. In fact, the periodic update is identified in the 1982 Water Supply Management Act- N.J.S.A. 58:1A-1 et seq. Examples of updates include:

- When underlying data or projections are updated the corresponding water demand or availability model should also be updated. For example, the metropolitan planning organizations such as the North Jersey Transportation Planning Authority will be revising their population projections using the 2020 census values, which will change the 2050 PCWS Demands model (discussed in Chapter 4) and will result in a more robust range of future water demand estimates.

- Global Climate Models and specifically downscaling techniques will continue to improve, and these revised future climate forecasts can be incorporated into water availability models for streams, reservoirs, and groundwater in the state.

- Continued implementation of the Water Quality Accountability Act, especially regarding water loss reductions through infrastructure improvements, will affect future water demands.

- The DEP has and will continue to improve other regulatory, financial and planning regulations which will in turn enhance a water systems' resilience and redundancy. These improvements will need to be addressed via updated planning efforts.

The DEP remains committed to a robust, evidence-based approach to ensuring an adaptive and resilient water supply for the state. This will enable DEP to meet challenges stemming from uncertainty head on via sound planning followed by direct implementation of targeted actions.

WATER MANAGEMENT DURING DROUGHTS

DEP has developed a robust approach to managing water supplies and demands in response to drought conditions. This section discusses the types of droughts, how droughts are monitored, and the management system for addressing drought impacts. More information is available at the New Jersey Drought Information website.

TYPES OF DROUGHTS

According to the National Drought Mitigation Center, drought is a normal, temporary, and recurrent feature of climate, which occurs practically everywhere in the world. Drought can be described as a period of unusual or persistent dry weather of a duration and magnitude that results in a shortage of water and adversely affects some activity, group, or environmental sector. For more information see the National Drought Mitigation Center. Drought is based on an assessment of existing conditions compared to some long-term average. There are different types of drought and all can occur in the New Jersey including:

- A meteorological (precipitation) drought occurs when recorded rainfall/snowfall is significantly below normal for a protracted period.
- An agricultural drought occurs when the soil-moisture deficit hinders crop growth.
- A hydrological drought occurs when low water supply becomes evident in the water system such as low stream flows, lake levels or unconfined aquifer groundwater depths.
- An ecological/environmental drought occurs when an ecological community is harmed by a lack of water (e.g., lowstream flows that reduce water quality and, in turn, stress fish and other aquatic organisms).
- A water-supply drought occurs when there is the potential for water demands to exceed available water supplies. This definition combines: (a) amount of water in storage; (b) anticipated water

demands; (c) the severity of the precipitation deficit; and (d) specific water sources available to an affected area.

Drought evolves over time and while all types of droughts can impact New Jersey, this Plan concentrates on water-supply droughts, which are the type that the DEP regulates. See Figure 7.2 for infographic of drought types and their relative relationships.

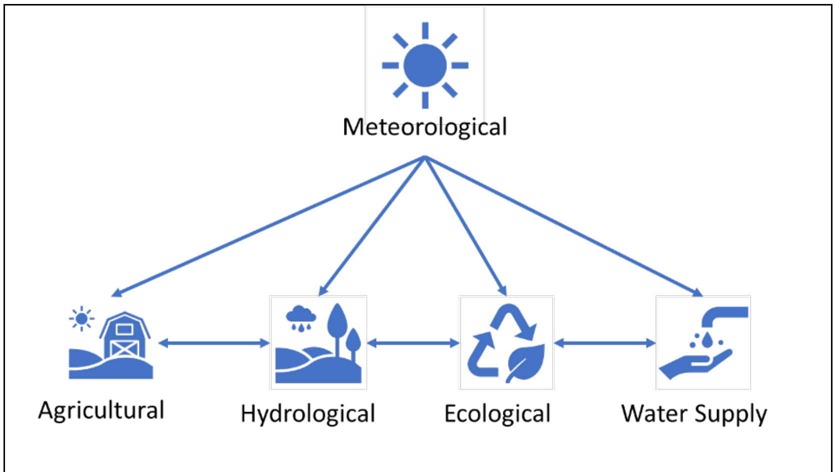


Figure 7.2 Drought type infographic.

DROUGHT MONITORING

Today, DEP regularly monitors various water supply conditions in six water supply regions, including regular communication with key water purveyors. The water supply conditions are monitored weekly, aiding the decision making of DEP and the Governor of New Jersey in declaring and changing drought status.

New Jersey's drought monitoring program grew out of an analysis of historic water-supply data and the State's experience and response to drought events during the early 1980s, mid- and late-1990s. Prior to the year 2000 decisions about the severity of drought conditions were based largely on precipitation deficits and storage in drinking water reservoirs as well as a broad assessment of data related to stream flows and groundwater levels. The DEP's actions during this period were dictated by the drought requirements of the Water Supply Management Act (N.J.S.A. 58:1A-1 et seq.) and the Water Supply Management Act Rules (N.J.A.C. 7:19).

In the fall of 1998, DEP recognized a developing precipitation deficit that extended through January of 1999, a relatively wetter period through spring, and a return of drought conditions by summer 1999 (Hoffman and Domber, 2004). The post-drought analysis revealed that the entire period (summer 1998 through fall 1999) was an extended drought interspersed with a few relatively wetter months that temporarily alleviated conditions. In fact, following a continuation of severely dry conditions that culminated in the 2002 water emergency, some observers considered the event to have been a multi-year drought interrupted by torrential rains associated with Hurricane Floyd in August of 1999.

This post-drought evaluation also showed the need for a more consistent method of comparing precipitation, stream flow and groundwater levels to historical values. Additionally, the State's effectiveness to manage the situation had been compromised by the lack of a means to easily compare the severity of drought conditions in different parts of the State and then communicate this information to the public. As a result, in 2000, DEP revised its methods, as described below, for monitoring and objectively assessing water-supply conditions, and communicating with decision makers and the public.

DROUGHT MANAGEMENT REGIONS

DEP divides New Jersey into six drought regions: Central, Coastal North, Coastal South, Northeast, Northwest and Southwest (Figure 7.3). The regional approach recognizes that precipitation patterns, water-supply sources,water demands, and existing infrastructure often vary considerably across New Jersey. The approach also acknowledges the distinction between sources of water, such as ground and surface water, and, more specifically, differences between surface water withdrawn from reservoirs and rivers, and between confined and unconfined groundwater diversions.

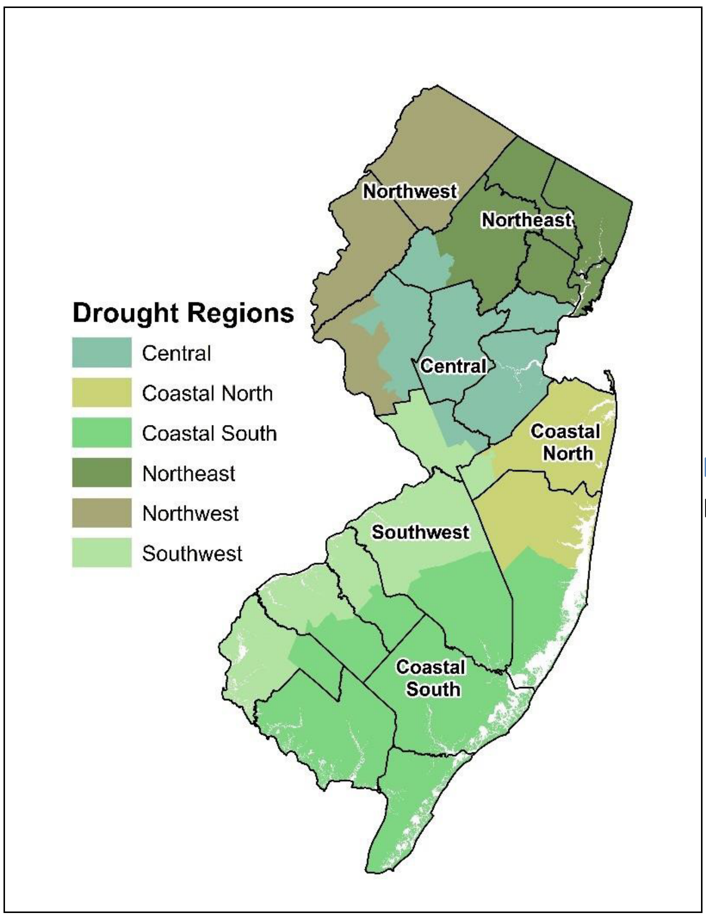


Figure 7.3 New Jersey Drought Regions.

For the purpose of administering and enforcing water use restrictions and other emergency orders when they become necessary, drought region borders align with municipal boundaries. This regional emphasis allows the State to tailor drought restrictions according to conditions within each designated region, thus

avoiding the imposition of restrictions in areas with sufficient supply. Drought region boundaries may be modified as needed to increase their usefulness. Specific drought event declarations do not need to be based solely on the defined six drought regions if specific event conditions warrant a different area. Drought region municipalities can be found at: DEP Municipality/Assigned Drought Region.

DROUGHT INDICATORS

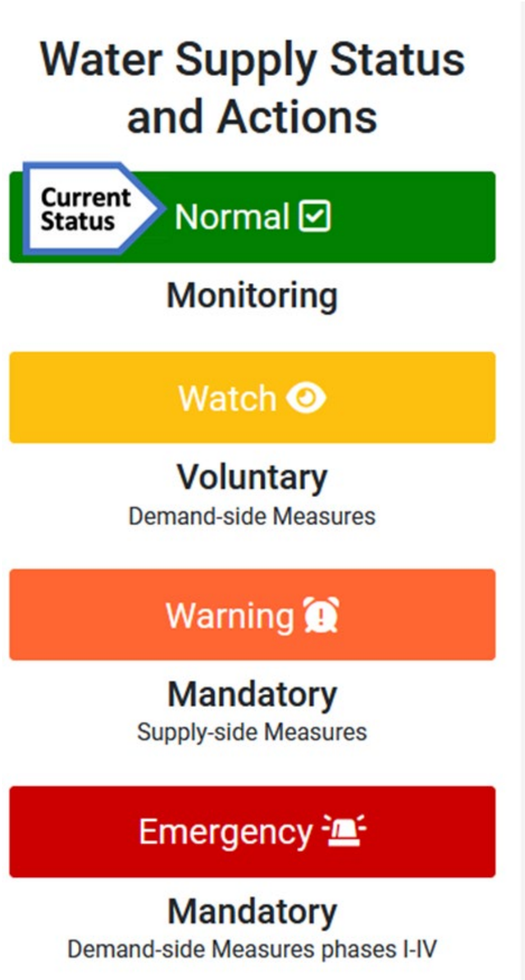
The tools DEP uses to assess waters supplies and monitor drought conditions have grown progressively more sophisticated in the last twenty years. Information about precipitation, stream flow, reservoir storage, and groundwater levels that are gathered from reference monitoring sites informs the State's drought indicators. The goal of each drought indicator is to summarize the status of a single factor affecting water supply in a given region. The indicators are designed to:

- integrate large amounts of available data about water-supply sources;
- be based on real-time data;
- be distributed quickly over the Internet; and
- relate accurate information about drinking water supplies to the public and decision makers.

The drought indicators do not automatically trigger a change in drought status; rather, DEP staff evaluates the indicators using best professional judgment, input from water suppliers, other drought-related resources, and other professionals in the formulation of an appropriate drought status (normal, watch, warning or emergency) for each region. The basis and background for the indicators and their application is summarized in New Jersey Geological and Water Survey (NJGS) Information Circular "New Jersey Water-Supply Drought Indicators", which is available at New Jersey Drought Indicators. The indicators themselves are updated weekly and they, and a wealth of other drought-related information, are available at New Jersey Drought Information.

ADMINISTRATIVE DROUGHT ACTIONS

When demand threatens to outstrip available water supplies, as with extended periods of below-average precipitation and/or above-average temperatures, DEP -- after evaluation of drought indicators in the State's six drought regions -- may designate a drought watch or drought warning condition to avert a more serious water shortage. New Jersey's governor may declare a state of water emergency when drought conditions persist (or in the event of a serious water system compromise or failure). Both DEP and a Governor's declarations are based on authorities within the Water Supply Management Act of 1981. In New Jersey, the relative status of water-supply conditions is classified as follows and shown in the infographic below:



- A normal condition indicates that an average or above-average amount of precipitation has fallen, or that the conditions relevant to water supply are not far enough below average to be of concern.
- A drought watch condition implies degraded, but not significantly compromised, water supply indicators. This status level was added to the indicators, though not formally adopted by rule, in 2000 following drought conditions experienced in 1998-1999. The purpose of the designation of a drought watch by DEP is to alert water-supply professionals to monitor the situation closely and prepare for the initial stages of drought response, as well as to boost awareness to the public so they are encouraged to conserve water. No regulatory restrictions are involved at this stage. Drought watches were declared for short periods of time in 2005, 2006, 2010, 2015 and most recently in 2022 with the declaration made in August 2022 and lifted in December 2022.
- A drought warning condition (N.J.A.C. 7:19-13.1(d), designated by the DEP Commissioner, reflects a continued worsening of water supply conditions. Under a drought warning, water-supply professionals actively monitor conditions and implement appropriate requirements, in accordance with N.J.A.C. 7:19. The drought warning requirements consist primarily of supply-side management measures designed to forestall a significant water shortage and avert a water emergency. Continued voluntary water conservation by the public is urged, though not required, at this time as well as cooperation by affected water suppliers. DEP also may exercise its non-emergency powers to order: tests of water system interconnections, water transfers between water systems, reductions of permitted passing flows and reservoir releases conducted in coordination with pertinent programs to conserve water in reservoirs, and other measures to ensure an adequate water supply. The most recent drought warning was declared for 14 counties in October 2016 and lifted for all but two counties in April 2017. The drought warning was lifted in full in August 2017.
- A state of water emergency (N.J.A.C. 58:1A-4) may be declared by the Governor when a potential or actual water shortage endangers the public health, safety and welfare. Under an emergency, DEP may impose mandatory water use restrictions by any party and may require specific actions to be taken by water suppliers. Such actions may include the interconnection of water systems; reduction, reapportionment or cessation of a particular supply; bans on adjustable water uses;

and additional water transfers between affected water systems and/or drought regions. A water emergency provides for a priority-based, phased system of mandatory water restrictions, which seek to reduce water consumption and preserve available supplies, while causing as little disruption as possible to commercial activity and employment. The phases are:

- **Phase I** limits water use for "non-essential" purposes (e.g., lawn/ landscape watering, non-commercial car and power washing, and swimming pool maintenance).
- **Phase II** involves selective indoor water rationing when the severity of the water emergency poses a substantial threat to the public health and welfare.
- **Phase III** requires further rationing to all sectors, including the selective curtailment of industrial water uses.
- **Phase IV**, the disaster stage, is reserved for when public health and safety cannot be guaranteed, and water quality is of utmost concern; maintenance of health facilities is at emergency levels; and industrial use is further curtailed, and selective closures may become necessary.

Note that the DEP has the authority to designate one or more drought status(es) on any region within the state, not just for a drought region. This authority allows the DEP to tailor its actions only on the impacted area and to take the most effective steps to address the issues specific to each geographic area and drought event.

DROUGHT DECISION SUPPORT TOOLS

A 2005 Interconnection Study found that if water transfers had been initiated sooner during past droughts (i.e., prior to 2005), all but two of the past five water emergencies since the 1960s could have been avoided. Working cooperatively with water suppliers to balance water supplies between areas of surplus and deficit in order to avert or lessen the impact of an impending water emergency is a critical water supply management tool. Therefore, as part of the 2016 Drought Warning, water transfers were ordered between several systems in order to preserve storage for those systems at highest risk. As a result, an estimated 1.8 billion gallons of water was preserved in critical reservoirs as a result of water transfers ordered between 2016 and 2017. An additional 2.8 bg was preserved from reducing reservoir passing flows.

The goals of the drought-related water transfers include:

- optimizing water diversions and transfers between systems to avert and mitigate drought-related water supply emergencies;
- identifying procedures to lessen the impacts on the State's water supply systems due to catastrophic losses; and
- recommending how to optimize existing system interconnections during "normal operations" and pre-drought to help increase overall water transmission efficiencies across the State.

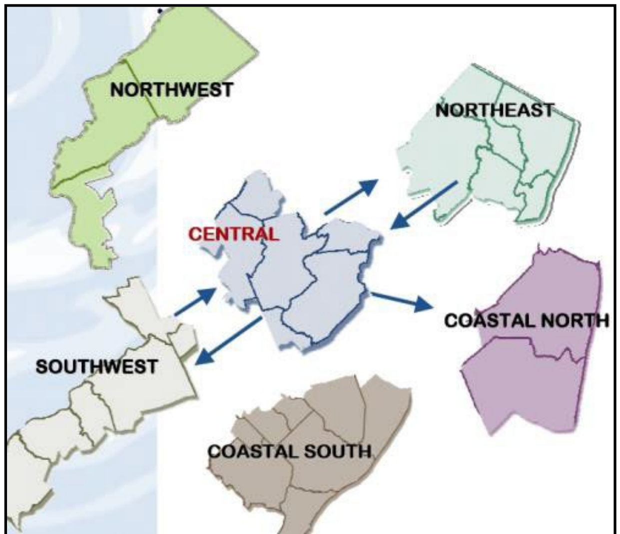


Figure 7.4 Water supply interconnections between drought regions.

However, one finding from the 2016-2017 drought was reluctance from many water suppliers to make the complete transfers as ordered due to concerns around water chemistry. Following the 2015 re-emphasis within DWSG on the implementation of the Lead and Copper Rule, many water suppliers became more aware of the potential for chemical interactions between different treated waters and how that could impact corrosion of lead in domestic plumbing or lead service lines. Since then, water suppliers, particularly in the Northeast region have improved their understanding of the chemical interactions of their waters. However, the concern of water quality impacts as a consequence of transferring water in ways beyond typical flows remains. Reversing flows at interconnections or distribution and transmission mains can disturb biofilms and mineral deposits within distribution infrastructure and can create poor water quality conditions for customers. While in acute emergency conditions transient water quality issues like this may be overlooked by some customers, it may still have overall damaging effects on public trust in the quality of their tap water. Regular maintenance and proactive efforts to enhance distribution water quality remain essential to minimize these disturbances when they do occur. Additional ongoing work by the DEP and which is referenced in the Plan, also identifies the need to expand the existing interconnection network to ensure that drinking water remains available even during major emergencies.

After the 2005 study, DEP began development of a regional surface water supply reservoir system model using RiverWare software. The software was developed by the Center for Advanced Decision Support for Water and Environmental Systems at the University of Colorado Boulder starting in 1986 and is funded primarily by the U.S. Bureau of Reclamation, the Tennessee Valley Authority, and the U.S. Army Corps of Engineers. It is utilized by numerous water utilities and management agencies across the county.

In New Jersey, the software has been used to create what is referred to as the New Jersey Model. This model simulates the major surface water supply systems in the Passaic, Hackensack, and Raritan River basins. It is used for both permit modification evaluations as well as to evaluate the effectiveness of drought or emergency response actions. The model can be used to optimize existing system interconnections during “normal operations” to help increase overall water transmission efficiencies and delay the onset of a drought declaration. The same model provides the ability to better manage water supplies during drought and water supply emergency periods, by testing different operational procedures. It was recently used to evaluate alternative operations for New Jersey Water Supply Authorities Raritan System during the Round Valley Project and to inform reservoir operations during the state’s first ever significant Harmful Algal Bloom on a major river- the Millstone in the summer of 2022 during a period of low precipitation. Additional capacity can be built into the regional RiverWare model to

investigate finished drinking water interconnections. The model is currently being expanded to include the major surface water reservoir supply systems in the Coastal North region (which is interconnected to the Raritan River basin) and could be used to evaluate the feasibility of forecast-based reservoir rule curves for drought management. Further research into modeling that can incorporate weather forecasting (e.g., National Weather Service 30-day projections) into drought management scenarios will also be useful. The model was also used to assess potential impacts of climate change on each system and its safe yield. The findings of this effort are discussed in Chapter 3.

While a few other reservoir simulation software programs exist, e.g., USACE HEC-ResSim, they are fundamentally different in their design and programming language and not interchangeable. The DEP has committed significant staff and financial resources to the RiverWare program over the last two decades and gained significant benefit from these efforts. Continued use of this modeling software is a key element to effectively manage the state's reservoir systems. Transition to one of the other software providers would likely require several years of startup efforts and significant cost, possibly putting these critical water supplies at risk.

PCWS SYSTEM RESILIENCE AND SUSTAINABILITY

The terms "resilience" and "sustainability" have many definitions and are sometimes conflated or confused for one another, but they address different aspects of system and societal management. Marchese et al. (2018) suggest that resilience addresses "the ability of a system to prepare for threats, absorb impacts, recover and adapt following persistent stress or a disruptive event." They suggest that sustainability is more of a long-term societal concept, involving continuing wellbeing as identified through social, environmental, and economic domains. Furthermore, New Jersey defines climate resilience specifically as "the ability of social and ecological systems to absorb and adapt to shocks and stresses resulting from a changing climate, while becoming better positioned to respond in the future." (NJDEP 2021) Using these concepts, we can recognize that a system that is not resilient isn't sustainable, but a system that is resilient is not necessarily sustainable. In other words, the system may be able to respond effectively to disruptive events but not achieve long-term sustainability internally or in its interactions with society. This section addresses resilience and sustainability of public community water systems (PCWS) from several perspectives: long-term infrastructure degradation; sudden infrastructure failure; and disruption from

Guard Lock on Delaware and Raritan Canal in Bulls Island State Park near Stockton.

hazardous conditions/extreme events and droughts. The first two categories are internal threats to service continuity, which are primarily under each system's control. The last category involves external threats that a system cannot control, but for which they can be prepared.

INFRASTRUCTURE INTEGRITY

Both nationally and in New Jersey, major issues have been identified regarding the integrity of drinking water infrastructure, including aging water distribution systems, components that have not been tested recently for functionality (e.g., valves, hydrants, interconnections), and treatment systems that may not be able to address new drinking water standards. In response, for more than 15 years, DEP has worked closely with the United States Environmental Protection Agency (USEPA), the New Jersey Clean Water Council and Water Supply Advisory Council (WSAC), the Jersey Water Works collaborative, the New Jersey Board of Public Utilities, the Department of Community Affairs and the Governor's office in multiple administrations and the Legislature to evaluate infrastructure needs and identify approaches to addressing these needs, including guidance, regulations and funding.

A major step forward occurred on July 21, 2017, when the 'Water Quality Accountability Act' (WQAA) became law in New Jersey and was subsequently amended November 8, 2021. This law, N.J.S.A. 58:31, sets standards for asset management, and other actions by certain water purveyors (i.e., PCWS with more than 500 service connections). Specifically, the WQAA requires:

- testing valves and fire hydrants to ensure proper function, including the ability to shut off sections of the system in the event of a major leak;
- development of cybersecurity programs to protect critical hardware/software used by PCWS to operate water systems, and manage customer billing information;
- mitigation plans for addressing notices of violation, including maximum contaminant level exceedances;
- annual notification of state authorities of compliance with all federal and state drinking water regulations; and
- development of an asset management plan consistent with best practice standards set by the American Water Works Association. This shall include dedicated funds to enable addressing the highest priority capital projects and annual progress reports that include the previous year's capital expenditures to address high priority projects and anticipated capital expenditures over the next 10 years.
    - Asset management plans shall be designed to inspect, maintain, repair, and renew infrastructure and shall include analysis of the condition and estimated service lines of water mains as well as an appropriate replacement cycle.

The WQAA is a major advance in water system infrastructure management; it is a national trend-setting approach. DEP works with water supply purveyors to ensure they have proper financial and technical assistance in meeting the requirements of the WQAA (see DEP-DWSG-WQAA). Meeting these requirements will help ensure water system resilience and the water supply of New Jersey, while reducing life cycle costs for system operation, maintenance, rehabilitation and replacement. Each step will

enhance system resilience, especially for the major components (e.g., large water mains, major valves, treatment systems) that, should they fail, would compromise services for large portions of a PCWS customer base. The reduction of life cycle costs will enhance sustainability of a PCWS, by reducing long-term pressures on customer rate schedules. Water audits, developed by the American Water Works Association (AWWA) are another tool that can greatly aid in the enhancement of water system resilience. Though not explicitly required by the WQAA, DEP intends to require the use of this methodology by all regulated under the WQAA.

It is recognized that meeting all requirements noted above will also increase short-term costs, with affordability implications for lower-income residential customers. For this reason, New Jersey Water Bank, a partnership between DEP and the New Jersey Infrastructure Bank, is continuing to issue low-interest loans for qualifying systems which include forgiveness of loan principal repayment. With this low-cost financing option, many more systems are able to undertake critical capital projects while maintaining affordability for their customers. With the advent of several federal programs to assist with infrastructure rebuilding, in response to the Covid-19 pandemic and national infrastructure needs, the Governor and Legislature have committed major funding to both the drinking water and wastewater infrastructure funding programs, to help reduce the customer costs of WQAA implementation and other mandates such as removal of lead service lines and compliance with new MCLs for PFAS compounds (PFOA, PFOS, and PFNA) and anticipated MCLs such as 1,4-dioxane.

To consolidate the numerous water infrastructure financing opportunities in recent years, DEP launched the Water Infrastructure Investment Plan (WIIP). This initiative is intended to highlight the low-cost financing that water systems, particularly those which are financially stressed, can leverage to minimize added costs of system modernization to meet evolving regulatory requirements. These costs would otherwise be borne in rates likely to negatively impact customers.

Both resilience and sustainability concepts are important in drinking water treatment. Resilience comes into play for systems that rely on water sources that could be contaminated by a major pollution incident that cannot be predicted, such as a chemical spill or HAB. River intakes and reservoirs with upstream developed areas are at risk; even if a system is fortunate for decades, a surprise event can force shutdown of the source, as has happened in other states. While wells are at lower risk of sudden contamination, PCWS that rely on wells can lose significant capacity if a major pollution problem is identified, as groundwater moves slowly and is far harder to clean up than a pollutant spill into surface water.

These regulatory and funding initiatives are in their early years at this time, but they will greatly accelerate water infrastructure rehabilitation and replacement in the 2020s. Preliminary findings from data submitted by water systems subject to the WQAA project approximately $12 billion in capital needs between 2023 and 2033. A report card summarizing the capital needs, and status of many water purveyors is available here.

DRINKING WATER SYSTEM STORAGE

Adequate finished water storage is key to a water system's resiliency. In addition to storage being a critical component in daily operations, it provides a backup source of supply should a water system experience an emergency such as loss of power, water main break, or well or treatment plant failure.

Water storage requirements for public community water supplies are specified under the Safe Drinking Water rules, N.J.A.C. 7:10-11 and the Water Supply Management Act Rules, N.J.A.C. 7:19-6. Per these regulations, the volume of storage required to be provided is based on factors such as whether a water system has multiple water supply sources/treatment facilities, auxiliary power, and interconnections with other public water systems in relation to the water system's average daily demand.

The regulations do allow some flexibility for a water system to meet these requirements. In cases where an approval has been granted to modify a water system's storage requirements, DEP has historically issued a Storage Waiver. These Waivers have been issued under a variety of circumstances including to very small water systems whereby regulatory storage requirements may impose an unnecessary hardship, to large water systems that are relying on another water system to provide its storage.

However, considering events that have occurred where resilience has been compromised, DEP will be re-evaluating the approval criteria that has been used in past issuance of Storage Waivers. It is anticipated that in order to help ensure water systems have adequate storage capacity to provide service during a water supply emergency, some Storage Waivers may be rescinded. In some cases, additional storage and/or alternate interconnections with other systems may need to be constructed or undertaken. Project costs could be economically significant for some water systems. DEP will be moving forward with a stakeholder initiative to solicit input on this proposal.

In addition, DEP is advancing a rule proposal to change some of the existing storage requirements. One of the proposed amendments will modify the term used for the basis of storage from "total storage" to "finished water storage capacity". As not all stored water can be utilized based on hydraulic constraints, "finished water storage capacity" will relate to that supply available for system delivery while maintaining required minimum system pressure. This change to the regulatory definition will be a benefit to public health and safety.

Another regulatory change contained within the rule proposal relates to water systems that are reliant on interconnections with other water systems to provide some or all of their storage. The proposed rule would require these systems to have a written agreement detailing the terms of their storage. Many water systems in the state have "handshake agreements" or other informal agreements where one system will provide sufficient storage for one or many systems which are interconnected. This practice results in several challenges, particularly with cost-sharing and liability around those storage facilities wherein resilience for each system may be lost if that storage is not properly maintained.

SEVERE WEATHER EVENTS

Water systems need to be able to prepare for, respond to, and recover from hazards and extreme weather events that threaten their operations. Coastal damages from Superstorm Sandy (2012) and river flooding from Hurricane Ida (2021) are good examples. The storm surge from Sandy damaged critical water supply infrastructure along the coast, and high winds compromised electrical and other energy distribution across much of the State, which in turn harmed the ability to supply water. The DEP instituted emergency response plans developed in accordance with N.J.A.C. 7:19-11.2. The impacts of and

experiences associated with Sandy and reinforced by Ida and other storms resulted in lessons learned and informed the steps taken since then to recover and become more resilient to future hazards, which include the need:

- for sufficient fuel to supply auxiliary power equipment during a multi-day interruption in power;
- to protect and/or harden all infrastructure within flood hazard areas (e.g., moving, elevating, or flood-proofing key infrastructure assets (such as with seals or membranes or within floodwalls) in ways that account for current and future climate change exacerbated flood and storm events);
- to update delineated flood hazard areas using the best available information and accounting for future increased precipitation events and sea-level rise;
- for secure communication among decision makers to quickly share critical information; and
- to proactively plan appropriate response measures and responsibilities prior to an event or hazard.

Many of these items have been instituted via Emergency Response Plans but additional revisions are likely needed and some may require regulatory updates.

In the wake of recent adverse weather events, DEP developed new guidance aimed at ensuring that repairs, reconstruction, new facilities, and operation/maintenance were focused on enhancing the resilience of our critical infrastructure. The guidance documents address Auxiliary Power, Flood Protection, Emergency Response/Planning, and Asset Management, available at DEP Water Supply and Asset Management. These documents present relevant material to address some of the core capabilities applicable to water systems regarding all hazards. These capabilities include establishing goals, threat assessment, response and resiliency planning, prevention, detection, investigation, and response and recovery protocols. In general, the guidance is applicable to both drinking water and wastewater systems. The long-term viability and effective operation of water systems can also be improved through asset management, as discussed in the previous section.

DROUGHT HAZARDS

Droughts generally do not harm the physical infrastructure of a water system, though they can render water sources unusable if water levels drop too much (e.g., a well that runs dry) or if the low flows create an adverse water quality event (such as the summer 2022 Millstone HAB event or the 2017-2018 elevated nitrate levels in the lower Passaic River). The primary concern is the ability to provide water which meets drinking water standards and simultaneously meets customer demands. Preparation for droughts can also require expenditures by the PCWS, such as enhanced interconnections, improved storage of raw or treated drinking water, or development of new wells to enhance firm capacity. Drought preparedness therefore imposes a financial cost on PCWS that will be passed on to customers through the rate schedules.

ENERGY PROVISIONS AND COSTS

Drinking water treatment can require significant amounts of energy. Nationally, USEPA estimates that drinking water and wastewater treatment account for 2 percent of national energy consumption, and

Delaware River looking downstream from the Calhoun Street Bridge in Trenton. This historic bridge crosses the Delaware River, connecting Trenton, New Jersey with Morrisville, Pennsylvania.

that energy costs are often 25 to 30 percent of all drinking water operating costs and can be as much as 40 percent. However, energy demands vary considerably based on the nature of the water supply (reservoirs, river intakes, shallow wells, deep wells), treatment needs due to source water contaminants, and topography of the service area (e.g., hills that require more energy to pump water to customers). Drinking water treatment costs are heavily influenced by raw water quality, and for similar raw water quality, smaller treatment plants have higher costs per volume (Grzegorzek et al., 2023).

Resilience is also an issue regarding potential energy disruptions, as seen with Superstorm Sandy. When electricity is suddenly unavailable from the energy utilities, a water system must continue operations by self-supplying energy. Water systems are thus faced with the requirement to build, service and provide fuel for generators that are only periodically needed, increasing both capital and operating costs. Some utilities are moving toward routine energy generation with renewable energy sources, such as solar and wind, but these sources have intermittency issues that must be addressed, such as with batteries, that will raise costs.

Sustainability issues arise where long-term energy costs substantially increase operating costs and therefore increase fiscal stress for the PCWS and for its customers. Energy costs could rise due to market conditions, PCWS decision making regarding which source waters to use (e.g., desalination of brackish water or saltwater), or drinking water quality requirements that force selection of energy-intensive advanced treatments.

UNCERTAINTY IN DEVELOPMENT TRENDS

In New Jersey, the potable water sector comprises over half of all water use and this pattern is likely to remain the same. Population forecasts are a fundamental component of water demand projections. These population forecasts come from the three metropolitan planning organizations (MPOs) that are responsible for transportation and other planning efforts in New Jersey: North Jersey Transportation Planning Authority, South Jersey Transportation Planning Organization and Delaware Valley Regional Planning Commission. Each MPO has its own methodology for population forecasting, but all include an assessment of likely births and deaths (age-cohort survival) and the movement of people to and from

municipalities (migration), including development expectations that would facilitate population growth. These forecasts through 2050 are discussed in Chapter 4.

Forecasts are not predictions. Rather, they are statements of possible futures based on trends and assumptions. Some of the trends, such as birth and death rates, are fairly stable through years of time, though the Covid-19 pandemic and deaths from opioids and fentanyl have shifted the death rate (annual drug-related deaths have roughly tripled in the last ten years). Migration between municipalities and states is not as stable, nor are development patterns. Prior to the Great Recession of 2007-2008, most housing starts were in suburban and exurban areas, while housing starts immediately after that period were heavily oriented to municipalities with greater than 90 percent developed lands (Evans, 2010). Housing affordability for prospective new homeowners and renters is a major factor in location preference, including whether people even stay in New Jersey. Evans (2017) noted that: “Millennials’ desire for more modestly sized housing options in walkable neighborhoods is not likely to disappear completely, even as they grow older and begin to raise families. Meanwhile, New Jersey is endowed with an over-supply of single-family homes on large lots, particularly in places that are dependent on driving.” The question is whether there will be a sufficient supply of housing to meet new expectations, such as walkable communities, or whether housing costs increase to the point where buyers move to other states.

Affordable housing projects (including “builders remedy” projects that include affordable units within otherwise market-rate developments) will increase opportunities for moderate income households in some areas. The creation of this housing is the direct result of the Mount Laurel decisions, several New Jersey Supreme Court rulings that have defined the responsibility municipalities have in providing a certain amount of affordable housing to people with low or moderate incomes. The location of these developments will be a result of the evolving market for new housing, proactive planning and zoning by municipalities, and in some cases court settlements. The Covid-19 pandemic also has affected locational preferences, at least temporarily, through acceleration of trends toward working at home (at least part time) or establishing sole-proprietor businesses that do not require offices. The possibility of major shifts to working at home raise questions about both residential and commercial office water demands, with the possibility of a significant shift from office use to residential use.

Finally, federal immigration policies have a major impact on New Jersey’s population, given that our state is nearly one-fourth foreign-born, much higher than the national average of 13.6 percent as of 2021 (Statista). New Jersey’s population grew by 5.7 percent from 2010 to 2020 (Census Bureau), but continued growth is not assured.

All of these factors result in significant uncertainty regarding population growth in New Jersey, generally, and for each of its municipalities and thus water demand. There is no method to create certainty out of this uncertainty. However, the uncertainty can be bounded through the use of scenarios that create higher and lower population projections for each set of assumptions regarding ongoing or changing trends. Van Abs et al. (2018) assessed the potential effects of changing demographic trends on county populations to the year 2040; foreign immigration and net domestic migration are both major factors. No municipal-level population forecast scenarios have been developed for alternative conditions. Therefore,

the approach used in this Plan is to periodically reassess population forecasts as they are generated by MPOs, while acknowledging that the planning horizon forecast (2050 for this Plan) has the greatest uncertainty.

SUMMARY

As previously mentioned, uncertainty is inherent in water supply planning, and plans must develop ways of assessing future actions that incorporate uncertainty. This chapter has noted numerous areas where DEP has and will continue to target in its efforts to reduce uncertainty and plan for adequate future water supply. Key areas include but are not limited to drought management, aiding in the efficient operation of New Jersey's reservoir systems and the transfer of raw and finished water between systems, and improving PCWS resilience and sustainability through administration of the WQAA. Currently New Jersey faces great challenges as the unknowns associated with climate change loom before us. Therefore, DEP is committed to ongoing research, model development, planning, monitoring, and event management that will make use of best available datasets related to water supply. This work will be the foundation that enables DEP to continuously work to reduce uncertainty around the core issues of climate change, drought, and water system resilience and sustainability.

Three specific items DEP intends to target as a result of this Plan include the following:

- ongoing research to inform a better understanding of drought (short-term, demand driven and multi-year) in the larger context of climate change and identification of approaches to preserve the water supply of the State and help ensure an adequate supply into the future;
- stakeholder initiative to solicit input on re-evaluation of the approval criteria that has been used for the issuance of Storage Waivers in the past; and
- sustained efforts to minimize issues associated with the mixing of treated water via interconnections between water systems in order to maximize resilience of regional water supplies, and to ensure that critical infrastructure is properly maintained and functioning.
    - During water supply emergencies it is vital that capability exists to move water quickly to regions in need.

Crowley's Landing on the Mullica River near Egg Harbor City.

CHAPTER 8: RECOMMENDATIONS AND ACTION ITEMS

Table of Contents

OVERVIEW

In recent years, New Jersey has repeatedly faced a confluence of water resource challenges that have tested our infrastructure, as well as the responsive capacity of our instituions. In the summer of 2022 extremely low precipitation and streamflow lead DEP to declare a Drought Watch- the first in over six years. During the same period, aging infrastructure failed resulting in massive water main breaks, water systems were required to address sources contaminated with per- and polyfluoroalkyl substances (PFAS), and rampant harmful algal blooms worsened by the extreme temperatures occurred. Individually these events would have been challenging, but combined, they severely tested the resilience of New Jersey's management of water resources. Such conditions are expected to persist or worsen in the years ahead, requiring DEP and its partner institutions to delicately balance the management of our water resources by carefully administering their planning, regulatory, investment, and incident response initiatives.

While 2023 proved to be a wetter year, it was also the third warmest on record. The spring season started out extremely dry and warm which resulted in numerous forest fires, agricultural stresses, and earlier than normal peak water demands. Fortunately, precipitation returned to more normal ranges over the summer and fall and supplies remained adequate. While the state avoided any formal drought action, sources continued to be challenged by new and emerging contaminants, repeated emergence of harmful algal blooms on water supplies, and water infrastructure emergencies occurred.

A car submerged from flood waters due to a water main break that occurred in Belleville in August 2022.

Through multiple legislative enactments, DEP is obligated and empowered to improve and protect water resources and water system infrastructure to ensure safe drinking water and system sustainability. The Water Supply Management Act (N.J.S.A. 58:1A-13) requires DEP to prepare a Statewide Water Supply Plan that assesses the state of our water supplies and identifies the policies necessary to ensure that the State and its water providers are adequately prepared for current and future water supply challenges. As discussed throughout this report, these challenges have been exacerbated by anthropogenic climate

change that will present as a progressive risk multiplier in the years ahead and which must be more fully considered in the development and implementation of water supply policy. In this Plan, DEP has identified the following actions and recommendations, which are interrelated and therefore also discussed in other chapters and appendices. The interrelationship of these actions and recommendations reflects the nature of the continuum of holistic water supply management.

As issues evolve and more information becomes available, the focus of Department action will change. Future Plan updates will address those changes if and when they occur.

HYDROLOGIC DATA, MONITORING, MODELS, AND ASSESSMENTS

The availability of long-term and real-time hydrologic datasets are critical pieces of information that DEP uses to quantify trends, characterize current conditions, build and calibrate models, and ultimately utilize to make focused and informed decisions and to update future water supply plans. The following items require continued, and in some cases expanded, financial, administrative, and technical support. To accomplish this, DEP will:

- Maintain, and expand where necessary, New Jersey's surface water, ground water and drought monitoring networks and assessment tools, both for water quantity and quality. Monitoring network data is used by multiple programs in DEP who contribute to their annual funding. The networks include:
    - Streamgauging Network including water quality monitoring;
    - Groundwater Network including ambient water quality monitoring;
    - Coastal Plain Synoptic Network; and
    - Drought Monitoring Network (for more information, see Chapter 5: Monitoring and Assessment of Water Resources section).
- Maintain, and expand where necessary, New Jersey's Ambient Groundwater Quality Monitoring Network (AGWQMN) and the associated data analyses. As feasible, emerging contaminants (EC) will continue to be added to the network's parameter list utilizing EPA's CCL, and UCMR promulgated lists as guidance or if an EC has been identified by the DEP as a priority. DEP will consider expanding the network to provide more complete and dense state-wide spatial coverage, target specific aquifers or watersheds, target deeper aquifers (typically associated with potable water diversions), and address changing land use types. This decision-making process for the AGWQMN would also be applied to the expansion of the salt-water intrusion monitoring network. If expanding the network will not address a specific groundwater quality need, DEP will consider designing and implementing new groundwater quality monitoring networks. DEP will periodically review hydrologic datasets to identify and assess trends and revise the monitoring network, summary metrics and indictors as needed (for more information, see Chapter 5: Monitoring and Assessment of Water Resources section and Chapter 2: Potential Water Losses to Contamination section).
- Continue and expand cooperative modeling, monitoring and data sharing between purveyors, dischargers, other pertinent agencies or groups and DEP to advance sound water supply management, particularly during instances of water quality track down and emergency events.

- Maintain, expand, and enhance the surface water supply reservoir system models to ensure that water availability/safe yield is accurately quantified. This process may include the development of forecasting and drought management tools used to improve reliability and accuracy of forecasts. Models may be expanded, or new models developed to assess finished water distribution storage, infrastructure, and pipe hydraulics (for more information, see Chapter 5: DEP Water System Resilience Actions section).
- Maintain, expand, and enhance groundwater models for both the unconfined and confined aquifers of New Jersey (for more information, see Chapter 2: Natural Water Resource Availability section and Chapter 3: Climate Change Initiatives for Water Supply section).
- Maintain, expand, and enhance the New Jersey Water Tracking Database so that accurate and comprehensive data sets can be used in Department models. It will also continue to update water demand forecasts for all sectors (for more information, see Chapter 5: Monitoring and Assessment of Water Resources section and Chapter 4: Estimating Future Water Needs section).
- Update and refine the stream low flow margin water availability assessments by
    - Updating the methodology to utilize HUC12 basins.
    - Incorporating current and projected climate change water availability impacts.
    - Assessing two regional areas identified as potentially limited.
        - Northeastern Region: Lower Raritan-Passaic
        - Southwestern Region: WMA 17 – Cumberland and Salem Counties (for more information, see Chapter 2: Surface-Water and Unconfined Aquifers section and Chapter 6: Stream Low Flow Margin Regional Focus Areas section)
- Build upon its analysis of the agricultural water-use metering pilot study results. While this study was limited, it indicated the potential for larger errors with estimated volumes (especially with estimated diversions greater than 2 million gallons per month). DEP will assess alternative approaches to improve agricultural water use data reported to DEP. Initial actions can be coordinated with the WMA17 LFM reassessment (for more information, see Chapter 4: Data Uncertainties section). These actions should continue through coordination between DEP, the NJ Department of Agriculture, Rutgers Cooperative Extension, National Resource Conservation Services, and the agricultural community.
- Work cooperatively with the Drinking Water Quality Institute and others to develop a comprehensive HAB water supply strategy and management plan, to complete a cyanotoxin rulemaking, and identify additional funding specific to HAB management for drinking water systems. In addition, the Division of Water Monitoring, Standards, and Pesticide Control will update the Integrated Water Quality Assessment Report (IR) Methods Document to identify methodology to assess new HABs narrative nutrient criteria interpretation. The IR assesses current water quality conditions, causes, and sources of water quality impairment needed to inform and guide water quality monitoring, restoration and protection efforts at drinking water sources effected by HABs (for more information, see Chapter 5: DEP Water System Resilience Actions section and Protecting New Jersey's Water Resources section).

CLIMATE CHANGE - WATER AVAILABILITY RESEARCH AND MODELING

This Plan and its recommendations benefit from the availability of sound and reliable climate change science. This science continues to evolve and DEP will remain committed to monitoring new developments, with a particularized focus on the regional and local impacts of climate change upon New Jersey and its natural resources. As new and additional climate change data becomes available, it will be utilized to improve DEP water supply models and monitoring methods to mitigate and manage climate change impacts to water resources more effectively. As such, DEP will:

- Support state and federal actions to expand and share climate science developments, including the projected impacts of climate change upon New Jersey's water resources; i.e. precipitation projections, temperature and sea-level rise for short, medium and long-term forecast periods and emission scenarios. (for more information, see Chapter 3: Overview of Climate Science section).
- Advance the spatial and temporal granularity of climate change water supply models. The assessments conducted as part of this Plan generally focused on annual changes over time and were conducted at larger watershed or statewide scales. Properly developed and calibrated models with decreased temporal and spatial scales can improve estimates of risk and identify specific alternatives or actions to mitigate those risks (for more information, see Chapter 3: Climate Change Impacts Relevant to New Jersey Water Supply section).
- Improve estimates of short-term changes in temperature and precipitation due to climate variability, which can lead to changes in drought severity and frequency and to develop monitoring approaches and management strategies to reduce risk (for more information, see Chapter 3: Temperature and Precipitation Nexus section and Chapter 7: Water Management During Droughts section).

- Continue quantifying risks to freshwater aquifers and recharge areas at risk from saltwater intrusion as a result of rising sea-levels and/or groundwater diversions and develop action plans to mitigate risks and maintain available supplies (for more information, see Chapter 3: Sea-Level Rise and Resulting Impacts section).

Paterson Great Falls National Historic Park in Paterson, New Jersey.

- Continue developing and refining DEP's Land Phase Model to improve estimates of and climate change induced impacts to groundwater recharge. DEP will also expand the model to estimate changes to evapotranspiration, runoff, baseflow and total streamflow resulting from climate changes to temperature and precipitation on both annual and shorter-term periods (for more information, see Chapter 3: Impacts to Unconfined Aquifer Recharge section).
- Periodically evaluate trends in hydrologic datasets to quantify impacts from climate change and utilize the results to adjust and improve monitoring networks, indicators, and models. Typical evaluation periods will be coordinated with Plan updates (e.g. once every five years), unless more frequent actions are appropriate (e.g. every one to two years for water use trends) (for more information, see Chapter 3: Climate Change Impacts Relevant to New Jersey Water Supply).
- Incorporate climate change findings into surface water supply reservoir system models to better identify how 'normal' operations or existing infrastructure may need to be modified/expanded/relocated/hardened to mitigate and reduce risk and increase system and regional resilience (for more information, see Chapter 3: Potential Impacts to Surface Water Reservoir System Safe Yields section).
- Advance research to better quantify how climate change will impact water demands, (e.g. longer growing seasons resulting from warmer temperatures) and incorporate findings into water supply models and plans. This would include potable, power generation, and agricultural and other non-potable irrigation uses (for more information, see Chapter 3: Overview of Climate Science section).
- Support research that informs climate change driven impacts to water quality that can impact water availability, e.g., harmful algal bloom frequency and occurrence and resulting drinking water treatment or raw water flow management requirements (for more information, see Chapter 3: Water Quality Impacts section). This research will include continuing model development to forecast storm events and potential impacts to water system operation and communities served.

CLIMATE CHANGE - INFRASTRUCTURE RESILIENCE RECOMMENDATIONS

DEP will develop recommendations and establish criteria to improve the resilience of water infrastructure and mitigate the adverse impacts of climate change upon the State's water supply, including through actions to:

- Reform relevant DEP policies, protocols or regulations pertaining to water infrastructure assessments and modifications, including, but not limited to:
    - Ensuring owners of community supply wells located within a climate adjusted flood elevation (CAFE) area modify well construction and associated infrastructure to prevent the flow of saltwater into the well or to allow saltwater to flow outside the well casing into potable aquifer(s).
    - Ensuring owners of surface water intakes, dams, and/or reservoirs within the CAFE area develop a sea-level rise-water availability vulnerability assessment and develop an action plan to mitigate the risk(s) identified.
    - Ensuring owners of critical water supply assets (pipelines, pump stations, power sources, etc) at elevations within the CAFE area develop a sea-level rise-water availability vulnerability assessment and develop an action plan to mitigate the risk(s) identified.
    - Aligning risk assessments and mitigation plans identified in this Plan with the 2021 New Jersey Climate Change Resilience Strategy (or current DEP guidance documents).
    - Ensuring regulated entities submit GPS location information for major infrastructure such as but not limited to treatment plants, pump stations, storage tanks, and large interconnections and valves consistent with DEP GIS standards.
    - Ensuring applicable water purveyors consider Climate Change impacts when developing/revising their asset management plans (for more information, see Chapter 3: Sea Level Rise and Resulting Impacts section).
- Update and revise applicable water related regulations and statutes to continue to address the emerging issues resulting from climate change and develop climate resilient water supplies (for more information, see Chapter 3: Summary section).
- Implement the New Jersey Water Bank's "Building Water Infrastructure Resilience," guidance that requires applicants for State Revolving Fund financing to evaluate the potential effects of climate change such as sea level rise, storm surges, and changes in precipitation patterns and intensity during the planning and design of water infrastructure projects; and to incorporate appropriate resilience measures into project designs. This resilience guidance will be updated as needed to remain consistent with water-related regulations and statutes (for more information, see Chapter 5: Adequate Asset Management section).

REGIONAL AND STATEWIDE WATER SUPPLY PLANNING AND PROTECTION

Water supply planning is a critical element to ensure that the state continues to have adequate supplies of acceptable quality to meet all its current and future needs and to balance human uses with ecological needs. As discussed in this NJSWSP, regional and statewide planning is adaptive and evolves as new information becomes available or issues emerge. As such, DEP will:

- Support the ongoing development and update of robust water supply plans (for more information, see Chapter 1).
- Further refine its overburdened community water supply analysis which could include detailed regional/community assessments and identifying additional opportunities to incorporate Environmental Justice Rules into water supply and drinking water permitting actions. DEP will consider working with state, county, and local agencies to sponsor additional research to define the scope of financial need for low-income private wells owners. DEP will also consider appropriating a supplemental fund to support low-income residents for the replacement of failing drinking water wells due to age, or installation of treatment for naturally occurring contaminants (for more information, see Chapter 5: Overburdened Communities and Private Wells section and Environmental Justice Recommendations section).
- Include a representative from the environmental justice community on the Water Supply Advisory Council. Council makeup is defined by the Water Supply Management Act. (for more information, see Chapter 5: Environmental Justice and Water Supply section).
- Expand on the existing Northeast Resilience Study finding to focus on key feasible recommendations that could be made statewide to enhance resilience especially considering issues such as, resolving uncovered finished water reservoirs, aging infrastructure, and harmful algal blooms (for more information, see Chapter 5: Interconnections, Conjunctive Use, Managed Aquifer Recharge, and Source Substitution section and Potential New and Expanded Sources of Supply section). Initial efforts will focus on the Northeast region.
- Expand upon the drinking water quality assessments that were included in the 2023-2028 NJSWSP (for more information, see Chapter 5: Statewide Safe Drinking Water Assessments section).
- Identify opportunities to expand its planning activities to include a holistic and watershed-based approach to source water protection. This could include one or more of the following items:
    - Review of, and update where necessary, its Source Water Assessment Program Plans. These actions may also consider expansion or enhancement to the SWAP planning process. This would include both surface water and groundwater sources.
    - Prioritization of funding sources to preserve open space upstream of drinking water intakes or in wellhead protection areas, including Green/Blue Acres funds.
    - Prioritization of funding for water quality restoration projects and initiatives through the 319 Grants program to identify and address nonpoint source pollutants upstream of drinking water sources. Funding sources include USEPA pass-through grants issued under Section 319(h) of the federal Clean Water Act and other federal and state funds that may be available for nonpoint source pollution related water quality restoration activities.

  - Consider water supply availability and drinking water quality criteria during review of Water Quality Management Plan applications and plans, as was past practice. Special consideration should be given to areas upstream of potable intakes or in Wellhead Protection Areas. This will require a rule change. Promotion of the balanced implementation of stormwater retention and groundwater recharge that preserves or improves water quality and availability, especially in areas of concern or where supplies may be limited (for more information, see Chapter 5: Protecting New Jersey's Water Resources section).

- Further coordination with the Parties to the 1954 Supreme Court Decree, the Office of the Delaware River Master, and the Delaware River Basin Commission to ensure that the water supply and instream flow needs of the basin are managed to balance in-basin and water supply needs. Priorities include establishment of a permanent Delaware and Raritan Canal diversion minimum of no less than 85 mgd, addition of regulatory provisions to ensure that balanced use, and to continue to provide saltwater protections to potable intakes and groundwater recharge areas (for more information, see Chapter 5: Delaware River Basin Commission section).
- Expand coordination with neighboring States on water supply issues. The Passaic and Hackensack watersheds have their headwaters located in New York State and they provide critical water supplies to northeastern New Jersey. DEP should assess water quality and quantity trends in the watersheds and work with New York State agencies and local governments to mitigate negative trends and to ensure that adequate quantities and quality of waters continue to flow downstream to New Jersey and its long-established and critical water supplies (for more information, see Chapter 5: Interstate Watersheds: Passaic, Hackensack, and Wallkill section).
- Recommend municipalities implement the Winter Best Practices to Reduce Road Salt Impacts to limit the levels of road salt that contribute to chloride contamination of ground and surface waters.

WATER POLICY MODERNIZATION

As discussed in Chapter 5 and throughout this Plan, DEP is obligated and empowered to improve and protect water supply resources and water system infrastructure to ensure water availability and the delivery of safe drinking water to homes and businesses. In some cases, the federal and state laws and attendant regulations that give rise to these obligations are fit for modernization to better position the State and its water providers to confront new and evolving water supply challenges. DEP identifies the following areas for revision:

- The Water Supply Management Act, N.J.S.A. 58:1A-1, was amended in 2002 to address temporary water allocation permits in Salem and Gloucester Counties; in 2004 to address provisions of the Highlands Water Protection and Planning Act (Highlands Act), N.J.S.A. 13:20; in 2006 to exempt the payment of water use registration annual fees for volunteer fire companies pursuant to N.J.S.A. 40A:14-70; and in 2008 to address provisions of the Environmental Enforcement Enhancement Act, N.J.S.A. 58:1A-16d. However, the Water Supply Allocation Permits rules (N.J.A.C. 7:19) have been readopted without substantiative change since 1995 and must be amended in response to enactments since. This includes proposed amendments to address issues recognized after the 2002 drought emergency. Several problems with the existing rule have been identified, which inhibit DEP and permittees from efficiently and effectively responding during drought emergencies. The formal addition of drought watch designation also warrants inclusion. Other amendments would modernize and simplify business process, increase

flexibility, incorporate stakeholder input and create consistency across Department programs and the Pinelands Commission (for more information, see Chapter 4: Data Sources section and Administratively Approved Withdrawals section).

- Explore opportunities for formalizing a cross-programmatic review process for potential impacts to wetlands from proposed water diversions greater than 100,000 gallons per day.
- Modify N.J.A.C. 7:10 to address raw water sampling and submission of results for all community water systems wells and intakes at a minimum of once per year as this data is critical to effectively manage drinking water quality and to ensure that water systems have the financial and technical resources needed to meet drinking water standards (for more information, see Chapter 5: Safe Drinking Water Program section and Safe Drinking Water Program Next Steps section).
- Modernize the New Jersey Safe Drinking Water Act, N.J.S.A. 58:10-1 et seq. and attendant rules to promote the development and administration of operating permits for New Jersey public water systems and better define requirements for backup water storage. Currently, whole system permits do not exist for entire water systems. Integral parts to these operations are permitted (e.g. withdrawals, discharges, or new treatment), however, there is no system-wide permit that is comprehensively reviewed on a regular basis. For example, this holistic review would assist with the earlier detections of problems with systems that may be generally in compliance but have underlying operational and maintenance issues that pose a public health risk (for more information, see Chapter 5: Safe Drinking Water Program section and Safe Drinking Water Program Next Steps section).
- Further modernization of the Water Quality Accountability Act (WQAA) at N.J.S.A. 58:31-1 et seq., including through:
    - Adoption of rules to accomplish several key WQAA policy objectives, such as establishing requirements for submitting AWWA Water Loss Audits, codifying Asset Management planning requirements, and providing clear enforcement powers to DEP.
    - Exploring WQAA amendments to:
        - Include water purveyors who indirectly serve systems with more than 500 service connections aka regional wholesalers or bulk providers,
        - Require some reduced level of asset management oversight for smaller systems, with less than 500 service connections,
        - Include certain wastewater systems, as recommended by the Joint Legislative Task Force’s Report on Drinking Water, as failure of wastewater infrastructure directly impacts water quality, and
        - Allocate new/additional resources (funds/FTE) to the WQAA program, which has not received resources since its initial passage and has drained existing resources from drinking water program/DOIT to implement the statutory requirements (for more information, see Chapter 5: Statewide Water Conservation Strategies section and Water System Resilience and Asset Management section).
- Support legislative efforts to explore the establishment of a revolving funding source that provides low- or no-interest loans or grants to eligible homeowners to ensure that replacement wells are accessible to residents in need. Due to the cost of replacement of aging wells, many

low-income private well owners, particularly those in overburdened communities, may not have the finances to hire a properly licensed well driller to ensure their home has a safely constructed, reliable well for water supply (for more information, see Chapter 5: Environmental Justice and Water Supply section).

- Support legislative efforts to explore the establishment of a permanent Low-Income Household Water Assistance Program (LIHWAP). LIHWAP temporarily offset water utility costs for New Jersey residents using federal funding. The program was part of the federal response to the Covid-19 pandemic and was intended to be temporary. Ensuring a permanent funding source will support low-income customers, help avoid water shutoffs, and assist PCWSs in setting rates necessary to fund infrastructure projects (for more information, see Chapter 5: Environmental Justice Recommendations section).
- Continue implementation and regulatory oversight over laws and regulations overseeing lead in drinking water. As the EPA promulgates the Lead and Copper Rule Revisions and the Lead and Copper Rule Improvements, DEP finalizes its own proposal for New Jersey-specific Lead and Copper rules and oversees implementation of the Lead Service Line Replacement Law. DEP will fulfill its obligations outlined by each of these pieces of rules and laws.
- Develop regulations outlined by DEP's Science Advisory Board to regulate the installation of Horizontal Directional Drilling (HDD) under the rules in N.J.A.C. 7:9D which govern wells as these activities pose risks to potable aquifers and surface waters and threaten current or future use. The State Well Drillers and Pump Installers Examining and Advisory Board, which oversees licensing of well drillers in New Jersey as well as advises DEP, has also recommended this rulemaking (for more information, see Chapter 5: Water Quality Regulatory Program section).
- Support legislative efforts to explore the establishment of certification or licensing requirements related to the installation of point-of-entry or point-of-use water quality treatment systems in homes (for more information, see Chapter 5: Safe Drinking Water Program Next Steps section).

ASSET MANAGEMENT AND RESILIENCE

Maintenance and improvement of infrastructure is a key element of effective and successful water supply management and critical to ensure the state has access to clean and plentiful drinking water. Proper asset management can reduce water incidents and emergencies, limit disruptions to customers, and reduce long-term costs. As such, DEP will:

- Continue to implement the requirements of the WQAA. This includes the technical support and maintenance of electronic portals and data management of Annual Certifications and Capital improvement Reports. Processes for evaluating and reporting the content of these submittals will continue to be developed. The Water Purveyor Report Card dashboard will continue to be updated on an annual basis (for more information, see Chapter 5: Water System Resilience and Asset Management section).
- Ensure annual reporting of American Water Works Association (AWWA) water loss audits by all community water systems regulated by the WQAA (for more information, see Chapter 5: Statewide Water Conservation section).

Delaware and Raritan Canal lock control gears in Bulls Island State Park.

- Further analyze community water system interconnections and infrastructure needs. DEP will develop a strategy that will include actions including, but not limited to, the following:
    - Continue and expand cooperation between purveyors and DEP.
    - Further evaluation of the water system vulnerability analysis previously covered in Chapter 2 to improve the accuracy of results with respect to systems reliant on unconfined groundwater.
    - Expand the water system vulnerability analysis to improve the methodology and expand it to include loss of surface or confined aquifer water sources.
    - Enhance and expand funding and online data submission options for DEP's geodatabase of critical water supply infrastructure to improve planning and emergency response capabilities (for more information, see Chapter 5: DEP Water System Resilience Actions section and Chapter 2: PCWS Vulnerability Assessment section).
    - Ensure water systems submit interconnection agreements to the DEP for review in accordance with N.J.A.C. 7:19-6.9(g). Each interconnection operation agreement should include the interconnection location, size, conditions for use and hydraulic capacity for both directions under the conditions expected for interconnection use.
- Support water system and legislative endeavors to expand financial support for drinking water infrastructure needs, including through regionalization, shared service arrangements, and rate realignment. The ongoing need for updating aging infrastructure to protect reliable drinking water supply and quality indicates that adequate resources are not currently available to water systems, which could result in rate shock scenarios without additional support.
- Review its storage waiver approval criteria to address emergent issues which may result in the revocation of previous approvals and new requirements for the addition of new storage and/or interconnections. These actions may also include definition changes and contract requirements

to the rule. All these actions will result in increased resiliency for water systems (for more information, see Chapter 5: Water System Resilience and Asset Management section).

- Continue to reduce risks posed from uncovered finished water reservoirs to ensure that all drinking water quality standards are met while maintaining adequate levels of finished water storage that meet regional needs (for more information, see Chapter 5: Potential New and Expanded Sources section).
- Continue to ensure that proposed but-not-built projects remain viable options if needed in the future. These include but are not limited to Dunker Pond, Six-Mile Run Reservoir, the Raritan Confluence project, Dundee dam, and Trap Rock Quarry. Additionally, DEP will ensure that water supply sources such as Greenwood Lake, Lake Wawayanda and Lake Hopatcong which were used in past drought emergencies remain viable options if needed for future emergencies (for more information, see Chapter 5: Potential New and Expanded Sources of Supply section).
- Work with partner agencies to expand efforts in support of regionalization/shared services for water systems, where appropriate. DCA continues to offer grant opportunities for systems to explore this option, but broader efforts are needed to ensure that water systems are able to keep up in a rapidly evolving regulatory environment. Sales of water systems to investor-owned utilities may be appropriate in certain scenarios. Regional/shared service approaches which retain public ownership of critical assets should also be considered, where appropriate
- Provide technical support to interagency endeavors to ensure emergency costs attendant to drinking water system operations are accounted in the course of water system and/or municipal fiscal planning.
- Continue to support new and expanded critical water supply projects discussed throughout this NJSWSP, such as but not limited to new and expanded interconnections, finished water storage, addressing uncovered finished water reservoirs, treatment plant upgrades, and contract for emergency and routine transfers (for more information, see Chapter 5: Water System Resilience and Asset Management section).
- Continue to maximize use of state and federal funding sources to meet water supply program priorities including:
    - Continue to leverage the New Jersey Water Bank to maximize funding from the State Revolving Fund to provide low-cost funding to water systems.
    - Continue to provide assistance to water systems serving small and disadvantaged communities via NJTAP to ensure that they have the ability to access funding from the water bank.
    - Support continued legislative investment in water infrastructure.
    - Explore establishment of a funding source to support capacity development and long-term viability of small water systems that do not have operational alternatives (for more information, see Chapter 5: Adequate Asset Management section and Environmental Justice Recommendations section).
- Continue to support and utilize water system interconnection assessments and modeling to:
    - Enhance the understanding of the connections between water systems by requiring the submission of information of all pertinent water system assets including geospatial locations (i.e. treatment plants, storage tanks, transmission main and interconnection

size and capacity). Though DEP currently has some of this data, it is not all required to be submitted and nor are submittals always in a format conducive to essential understanding of those connections.

- Data Management and Security – DEP will seek to require specific data format submission specifications to allow facilitation of statewide or regional assessments. These submissions would be stored in a secure file format and location as much of the water system information is considered sensitive (for more information, see Chapter 5: Interconnections, Conjunctive Use, Managed Aquifer Recharge, and Source Substitution section).

POLICIES AND PRIORITIES FOR THE EFFICIENT USE OF WATER

The practices and policies identified below are discussed in this NJSWSP and lead to the responsible and efficient use of the state's water resources. As such, DEP will:

- Continue to facilitate the use and development of Managed Aquifer Recharge (MAR) to meet water supply needs and address shortages, where appropriate. DEP programs will be coordinated to ensure that the use of MAR is a viable alternative, especially in the coastal regions where confined aquifers are present, water demands can increase significantly during the summer months, and where surface water or groundwater resources are threatened by sea-level rise and salt-water intrusion (for more information, see Chapter 5: Interconnections, Conjunctive Use, Managed Aquifer Recharge, and Source Substitution section).
- Discourage new or increased allocation for highly consumptive non-potable uses especially in areas with known or potential water availability and/or water quality concerns (for more information, see Chapter 4: Water Withdrawals and Use section).
- Continue to require the use of the lowest quality of water available for intended use, pursuant to N.J.A.C. 7.19.

PUBLIC OUTREACH

DEP is committed to continuing public education and engaging with people and communities we serve on key water supply issues and initiatives. Though many residents do not consider drinking water issues in their daily lives, its importance cannot be overstated. As such, DEP will:

- Develop this Plan into an online interactive document such as a story map to illustrate the findings of this iteration of the Plan and as a way of communicating updates following its publication.
- Continue to provide and improve educational tools to inform the public about water supply issues, drought management, and water conservation and efficiency strategies - DEP Water Conservation. Examples of water conservation programs DEP has implemented include the New Jersey Water Savers program and the Water Champions program. DEP also continues to promote statewide water conservation and efficiency through involvement in the Sustainable Jersey program and the Environmental Protection Agency's (USEPA) WaterSense program. Tailored programs may also need to be developed to address community or region specific issues; e.g. OBCs or vacation/shore communities. For more information, see Chapters 5 and 7.

- Continue to implement the AmeriCorps New Jersey Watershed Ambassadors Program to help the DEP conduct education and stewardship projects that relate to sources of drinking water Watershed Ambassador AmeriCorps program.
- Collaborate with partner agencies like Rutgers University and Sustainable New Jersey in their conservation efforts including key public outreach programs such as model ordinance development for municipalities and rain barrel initiatives.
- Continue to provide education resources for private well owners and continue to update and improve existing tools - New Jersey Private Well Information.

View of the Wading River from Evans Bridge located in the Wharton State Forest in the New Jersey Pine Barrens.

CONCLUSION

New Jersey's 9.3 million residents, $800 billion economy, and diverse ecosystems are dependent upon a clean, secure, and resilient water supply in order to meet daily needs, expand economic opportunities, enhance standards of living, improve public health, and restore ecosystems.

While New Jersey must contend with new and increasing water supply challenges now and in the years ahead, the state's public and private water supply managers will draw from a strong foundation. Through the analyses presented in this Plan, DEP has found that New Jersey has sufficient quantities of water to meet current and reasonably anticipated future needs in most regions of the state. However, the continued availability of water resources and their readiness for use is dependent upon intentional and consistent actions to conserve, bolster, and actively manage public and private water supplies. Through active water supply management that includes continuous investments in aging water infrastructure, renewed focus on sound asset management, proactive adaptation measures to respond to the worsening impacts of climate change, and implementation of the policy supports identified in this Plan, New Jersey can better protect and improve its water resources, avoid water scarcity, assure water security, and continue to expand economic opportunities and improve standards of living for all residents.

New Jersey residents, communities, businesses, and institutions are as connected and interdependent as the water resources we share, and each of us must be careful stewards of this precious, finite resource. As public and private water supply managers work to implement the measures identified in this Plan in the years ahead, DEP stands as a partner to every community, water system, business, institution, and member of the public we serve. As DEP does its part to discharge the recommendations made here, the Department will closely monitoring new developments and update this Plan periodically to ensure that the most up-to-date data and best available science are utilized to address our water supply needs and challenges. Together, we will ensure that current and future generations of New Jerseyans have access to a clean, secure, and resilient supply of water.

Glossary

ACCRETIVE means the addition of water to a watershed, generally through the imports of either fresh water or sewage or reclaimed wastewater.

ADMINISTRATIVELY APPROVED ABILITY is the amount of water a water supplier is approved to deliver under current regulatory permits.

ADVECTIVE TRANSPORT is the transport of a substance or quantity by bulk motion of a fluid. In the context of this Plan it is a method used to simulate areas where groundwater may be prone to salt-water migration.

AGRICULTURAL CERTIFICATION means the document obtained from the County agricultural agent if a person diverts ground and/or surface water in excess of 100,000 gallons per day for agricultural, aquacultural or horticultural purposes.

AGRICULTURAL REGISTRATION means the document obtained from the County agricultural agent if a person has the capability to divert ground and/or surface water in excess of 100,000 gallons per day for agricultural, aquacultural or horticultural purposes, but who diverts less than this quantity.

AQUACULTURE includes the propagation, rearing, and subsequent harvesting of aquatic animals (generally fish or shellfish, either freshwater or marine) in controlled or selected environments, as well the processing, packaging, and marketing of the harvested animals. Common freshwater aquaculture species include trout, tilapia and catfish. Common marine aquaculture species include oysters, mussels, crabs and shrimp.

AQUIFER means any water-saturated zone in sedimentary or rock stratum which is significantly permeable so that it may yield sufficient quantities of water from wells or spring in order to serve as a practical source of water supply.

AQUIFER RECOVERY (AR) is a form of MANAGED AQUIFER RECHARGE where water is injected into a well without recovery.

AQUIFER STORAGE AND RECOVERY (ASR) is a form of MANAGED AQUIFER RECHARGE where water is injected into a well for storage in the aquifer and recovery form the same well.

AQUIFER STORAGE TRANSFER AND RECOVERY (ASTR) is a form of MANAGED AQUIFER RECHARGE where water is injected into a well for storage in the aquifer and recovery from a different well or wells.

CONFINED AQUIFER is an aquifer which contains groundwater confined under pressure between relatively impermeable or significantly less permeable material so that the water level in a well that is open to the confined aquifer only rises above the top of the aquifer.

CONSUMPTIVE WATER USE means the use of water in such a way that a portion of the water used is lost to evaporation, transpiration, incorporation in product, etc., and not discharged to any location.

CRITICAL WATER SUPPLY AREA or **CRITICAL AREA** means a water supply area of concern in which it is officially designated by the Commissioner of the DEP, after public notice and a public meeting, that adverse conditions exist, related to the ground or surface water, which require special measures in order to achieve the objectives of the Water Supply Management Act. The DEP will not issue new or increased diversions from affected aquifers within an area of critical water supply or from wells located outside, but that affect the area of critical water supply concern, except for certain cases as defined at N.J.A.C. 7:19-8.3(i) through (k). The DEP may require that diversions be reduced if an alternative supply is made available.

DEPENDABLE YIELD means the yield of water by a water system which is available continuously throughout a repetition of the most severe drought of record, without causing undesirable effects.

DEPLETIVE WATER USE means the withdrawal of water from a water supply resource (ground or surface water) where the water, once used, is not discharged to the same water supply resource in such a manner as to be useable within the same watershed.

DROUGHT means a condition of dryness due to lower than normal precipitation, resulting in reduced stream flows, reduced soil moisture and / or lowering of the potentiometric surface in wells.

EVAPOTRANSPIRATION means the water lost to the atmosphere from the GROUND surface, EVAPORATION from the capillary fringe of the groundwater table, and the TRANSPIRATION of groundwater by plants whose roots tap the capillary fringe of the groundwater table.

FIRM CAPACITY means the peak daily demand of water a public water supply can meet through pumping equipment and/or treatment capacity (excluding coagulation, flocculation, and sedimentation) when the largest pumping station (including a well) or treatment unit is out of service.

FRESH WATER means all non-tidal and tidal waters generally having a salinity due to natural sources of less than or equal to 3.5 parts per thousand at near high tide.

HYDROGEOLOGY means the field of geology that deals with the distribution of movement and groundwater in the soil and rocks of the Earth.

HYBRID AQUIFER STORAGE TRANSFER AND RECOVERY (HASTR) is a form of MANAGED AQUIFER RECHARGE where water is injected into a well for storage in the aquifer and recovery from both the injection wells and neighboring wells.

HUC11 refers to an 11-digit Hydrologic Unit Code drainage area. This is a multi-level, hierarchical drainage system defined by the U.S. Geological Survey. There are 150 HUC11s onshore in NJ with an average size of 51.9 square miles.

HUC14 refers to a 14-digit Hydrologic Unit Code drainage area. This is a multi-level, hierarchical drainage system defined by the U.S. Geological Survey. There are 921 HUC14s onshore in NJ with an average size of 8.5 square miles.

INTERBASIN TRANSFER means the movement of water (as raw, treated or used water) from one watershed to another.

INTERCONNECTION means a water supply connection with another water supply system or systems. An interconnection may be for routine or non-routine (e.g., emergency) supply purposes.

LOW FLOW MARGIN means the difference between normal dry-season flow (September Median Flow) and the 7Q10 low flow.

MANAGED AQUIFER RECHARGE means the injection of water into a well for a recharge purposes. The water may not be recovered as in Aquifer Recharge (AR). The injected water may be recovered from the same well site as in Aquifer Storage and Recovery (ASR), it may be recovered from a different well or wells as in Aquifer Storage Transfer and Recovery (ASTR), or it may be recovered from both the injection well and neighboring wells as in Hybrid Aquifer Storage Transfer and Recovery (HASTR).

MULTIPLE SOURCES means one or more production wells, surface water intakes, or interconnections or a combination of wells, surface water intakes or interconnections utilized to meet the demands of a public community water system.

NATURAL RESOURCE AVAILABILITY means the naturally occurring baseline ability of a water resource to maintain a pattern of water flow and storage.

NJWaTr refers to the New Jersey Water Transfers Database developed by the U.S. Geological Survey and maintained by the DEP to track water withdrawals, use, interbasin transfers, treatment, and discharge in New Jersey.

NON-CONSUMPTIVE WATER USE means that portion of water use which is not lost to evaporation, transpiration, incorporation in product, etc. This volume isavailable for use by a downstream user.

NON-REVENUE WATER means the difference between the annual volume input into the water supply system and billed authorized consumption (includes billed metered and billed unmetered consumption).

POTABLE WATER means water that does not contain objectional pollution, contamination, minerals, or infective agents and is considered satisfactory for domestic consumption using conventional water treatment processes (e.g., chemical coagulation / flocculation, clarification, filtration, disinfection).

PURVEYOR means any municipality, authority, commission, company or person who owns or operates a public community water supply system.

PUBLIC COMMUNITY WATER SYSTEM or PCWS means a public water system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents. Examples include mobile home communities and municipalities.

PUBLIC NONCOMMUNITY WATER SYSTEM or PNCWS means a public water system used by individuals other than year around residents for at least sixty days of the year. A noncommunity water system can be either transient or nontransient. A nontransient noncommunity water system serves at least twenty-five of the same people over a period of six months during the year, such as schools, factories, and office buildings. A transient noncommunity water system is a system that serves year around for at least sixty days of the year but does not serve the same individuals during that time period. Transient noncommunity water systems include rest stop areas, restaurants, and motels.

RWBR (Reclaimed water for beneficial reuse) means water that has been treated to meet restricted access or public access reuse requirements as specified in a NJPDES permit where the NJPDES permit authorizes that water to be directly reused for non-potable applications in place of potable water, diverted surface water, or diverted groundwater.

RESERVOIR means a large natural or artificial lake used as a source of water supply, either directly or through release and stream flow to a downstream point of withdrawal.

SAFE YIELD means the yield maintainable by a surface water system (especially where supported by a reservoir) continuously throughout a repetition of the most severe drought of record, after compliance with requirements of maintaining minimum passing flows, assuming no significant changes in upstream or up-basin depletive withdrawals or drought conservation actions.

SEPTEMBER MEDIAN FLOW means half of the September flows will be higher and half will be lower during a critical time when streamflow tends to be the lowest in New Jersey.

SOURCE WATER means the surface water (streams, rivers, lakes and reservoirs) or groundwater (aquifers) that supply water to a public water system for drinking or other domestic purposes.

SOURCE WATER ASSESSMENT AREA (GROUNDWATER) means the area from which water flows to a well within a certain time period. Each ground water source water assessment area in New Jersey contains three tiers, labeled as Tier 1, Tier 2, and Tier 3. Tier 1 is a two-year time of travel, which means the ground water within this tier flows to the well within a two-year time period. Tier 2 is a five-year time of travel; the ground water within this tier will flow and reach the well within five years. The final tier, Tier 3, is a twelve-year time of travel, in which the ground water within this tier will flow and reach the well within twelve years.

SOURCE WATER ASSESSMENT AREA (SURFACE WATER) means the area upstream of a surface water intake including the tributaries and headwaters.

STREAM LOW FLOW MARGIN METHOD is the approach developed by DEP to define unconfined aquifer and non-reservoir surface water availability and is described in NJGWS Publication TM 13-3, Using the Stream Low Flow Margin Method to Assess Water Availability in New Jersey's Water-Table-Aquifer Systems. Also referred to as LFM or low flow margin method.

SURFICIAL AQUIFER (see UNCONFINED OR SEMI–CONFINED AQUIFER)

TRANSPIRATION is the process by which moisture is carried through plants from roots to small pores on the underside of leaves, where it changes to vapor and is released to the atmosphere.

TREATED WASTEWATER means the treated spent water of a community. From the standpoint of source, it may be a combination of the liquid and water-carried wastes from residences, commercial buildings, industrial plants, and institutions, together with any groundwater, surface water, and storm water that may be present. Consistent with available information, municipal wastewaters will be categorized into primary level treatment, secondary level treatment, and advanced treatment.

UNACCOUNTED-FOR-WATER means water withdrawn by a purveyor from a source and not accounted for as being delivered to customers in measured amounts.

UNCONFINED OR SEMI–CONFINED AQUIFER means an aquifer close to the land surface with continuous layers of material with permeability in the high to low range, extending from the land surface to the base of the aquifer, where the water table (the upper surface of the saturated zone) is at or near atmospheric pressure.

USER means any person or other entity which utilizes water, whether authorized or not.

WATER ALLOCATION PERMIT means the document required for the diversion of ground and/or surface water in excess of 100,000* gallons per day for a period of more than 30 days in a 365 consecutive day period, for purposes other than agriculture, aquaculture or horticulture. This includes water diversions for public water supply, industrial processing and cooling, irrigation, sand and gravel operations, remediation, power generation, and other uses.

WATER LOSS means difference between the amount of water placed into a distribution system and the total authorized water use (i.e., water that does not reach a valid user or use, whether billed or not billed).

WATERSHED means a geographic area in which all water, sediments and dissolved material drain to a particular receiving body.

WATERSHED MANAGEMENT AREAS means the 150 HUC11 drainage basin boundaries in New Jersey grouped into 20 regions with similar characteristics and/or discharge locations and used to target and focus statewide and regional watershed management activities.

WATER SUPPLY DEFICIT means the amount or amounts by which the available resources fall short of a given demand.

WATER SUPPLY SYSTEM means a physical infrastructure operated and maintained to deliver water on either a retail or wholesale basis to customers.

WATER SYSTEM IMPROVEMENT means any action which increases the capacity, capability, or efficiency of a water system.

WATER TABLE means the water surface in the upper most part of the water saturated zone which is at atmospheric pressure.

WATER TABLE AQUIFER means an aquifer which carries water at atmospheric pressure at the top of the saturated zone, the water table. See also UNCONFINED AQUIFER.

WATER USE REGISTRATION means the document required for any person with the capability to divert in excess of 100,000 gallons of water per day, but who diverts less than this quantity for purposes other than agriculture, aquaculture or horticulture.

WELL HEAD PROTECTION AREA or WHPA is the area from which a well draws its water within a specified timeframe.

XERISCAPING means the practice of the landscaping design so that little or no irrigation is needed.

7Q10 FLOWS means the seven-day, consecutive low flow with a ten-year (10 percent probability) return frequency; the lowest stream flow for seven consecutive days that would be expected to occur an average of once in ten years.

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State of New Jersey
Department of Environmental Protection

2024 NEW JERSEY STATEWIDE WATER SUPPLY PLAN

APPENDIX A

STREAM LOW FLOW MARGIN (LFM) METHOD RESULTS

Draft for Public Comment

STREAM LOW FLOW MARGIN (LFM) METHOD RESULTS

Table of Contents

LFM METHOD DESCRIPTION

The Low Flow Margin (LFM) method is used by DEP to estimate the amount of water-table (unconfined) aquifer and surface water[1] that can be sustainably withdrawn in each HUC11 drainage basin (Snook, Domber, & Hoffman, 2013). This approach assumes that a certain amount of streamflow can be lost without causing adverse ecological and water supply impacts. LFM is designed to be an estimate of water availability at low-flow periods. The amount of water that can be lost via depletive or consumptive water uses[2] is estimated as a percentage of the difference between the September median flow and the 7Q10 flow. The flow statistics are calculated for each of New Jersey's 151 HUC11 drainage basins. September median flow is the average monthly flow in September where half of the observed Septembers are higher and the other half are lower. 7Q10 is defined as the annual seven-day minimum flow that occurs on average once in ten years. The difference between the September median and the 7Q10 is referred to as the margin (see LFM column in A tables). A percentage of the LFM is determined as a planning threshold for excessive depletive and consumptive loss (known as Available Water). This Plan uses 25% of the LFM as a planning threshold, reserving the remaining 75% for ecological maintenance and downstream flows. If a HUC11's net water loss exceeds this threshold, it is considered to have potential water-availability shortages, and further analysis is needed.

The 25% threshold used in the 2017 Plan was reconfirmed based upon a more detailed analysis of daily streamflow at a set of 24 USGS continuous record stream gages. The reanalysis was completed using the Ecologic Limits of Hydrologic Alteration or ELOHA method and specifically the New Jersey Hydrologic Assessment Tool (NJHAT). See Table X for a summary of results of this analysis which showed an average of 23% for all the basins with a range of 10% to 40%. Based upon the larger uncertainties associated with the method and data, it is reasonable to use the same 25% value for this analysis.

Table X: Calibration of the Stream Low Flow Margin Method Using NJHAT

ID	Gage Number	Name	Baseline Period	Drainage Area (mi²)	Stream Type Classification	Stream Flow Reduction (CFS)	Stream Flow Reduction (mgd)	* September Median (mgd)	* 7Q10 (mgd)	Stream Stat Violation	LFM Difference of 7Q10 and September Median (mgd)	** Percent of LFM
1	**01464000**	**Assunpink Creek @ Trenton**	1923-1956	91	A	3.891	2.51	26.5	7.97	DL4	18.53	14%
2	**01410150**	**East Branch Bass River near New Gretna**	1978-2005	8.11	D	0.581	0.38	7.11	4.17	DL4	2.94	13%

[1] The LFM method does not consider surface water that is regulated in a surface water supply reservoir system (aka a system with a defined safe yield).

[2] Consumptive loss means water is removed from the water supply resource (ground or surface water), used, and lost to the atmosphere, generally through evapotranspiration. Depletive loss means the withdrawal of water from a water supply resource where the water, once used, is not discharged to the same water supply resource in such a manner as to be useable within the same watershed (e.g., exported out of the watershed); it may be available for use elsewhere in the state if discharged to fresh waters.

ID	Gage Number	Name	Baseline Period	Drainage Area (mi^2)	Stream Type Classification	Stream Flow Reduction (CFS)	Stream Flow Reduction (mgd)	* September Median (mgd)	* 7Q10 (mgd)	Stream Stat Violation	LFM Difference of 7Q10 and September Median (mgd)	** Percent of LFM
3	**01440000**	**Flatbrook near Flatbrookville**	1923-2005	64	A	4.9	3.17	13.57	4.75	ML6	8.82	36%
4	**01411000**	**Great Egg Harbor River @ Folsom**	1925-1970	57.1	B	5.5	3.55	28.44	14.01	FH10/DL1	14.43	25%
5	**01408000**	**Manasquan River @ Squankum**	1931-1956	44	A	3.5	2.26	21.97	10.83	ML8	11.14	20%
6	**01409400**	**Mullica River near Batsto**	1957-2005	46.7	B	6	3.88	25.85	9.39	ML4	16.46	24%
7	**01457000**	**Musconetcong River near Bloomsbury**	1921-1972	141	B	9	5.82	67.86	29.57	DL1	38.29	15%
8	**01379000**	**Passaic River near Millington**	1921-1979	55.4	A	2.5	1.62	9.51	1.81	ML5	7.7	21%
9	**01443500**	**Paulins Kill @ Blairstown**	1921-1975	126	A	11.5	7.43	34.9	10.59	ML7	24.31	31%
10	**01477120**	**Racoon Creek near Swedesboro**	1966-2005	26.9	C	2	1.29	10.99	4.75	ML4/ML6/ML8	6.24	21%
11	**01384500**	**Ringwood Creek near Wanaque**	1934-1978	19.1	C	0.85	0.55	2.13	0.24	ML5	1.89	29%
12	**01380450**	**Rockaway River @ Main Street @ Boonton**	1937-1959	116	A	14	9.05	38.78	9.61	ML6	29.17	31%
13	**01465850**	**South Branch Rancocas Creek @ Vincentown**	1961-1975	64.5	B	3.6	2.33	19.35	5.75	DL1	13.6	17%
14	**01396500**	**South Branch Raritan River near High Bridge**	1918-1970	65.3	A	4.5	2.91	29.73	14.24	ML4	15.49	19%
15	**01408500**	**Toms River near Toms River**	1928-1963	123	B	8.5	5.49	73.68	42.93	DL1	30.75	18%
16	**01411300**	**Tuckahoe River @ Head of River**	1969-2005	30.8	C	1	0.65	10.99	4.65	ML5	6.34	10%

ID	Gage Number	Name	Baseline Period	Drainage Area (mi^2)	Stream Type Classification	Stream Flow Reduction (CFS)	Stream Flow Reduction (mgd)	* September Median (mgd)	* 7Q10 (mgd)	Stream Stat Violation	LFM Difference of 7Q10 and September Median (mgd)	** Percent of LFM
17	**01409280**	**Westecunk Creek @ Stafford Forge**	1979-1988	15.8	D	3.5	2.26	14.28	8.67	ML8/FH3	5.61	40%
18	**01381500**	**(1) Whippany River @ Morristown**	1921-1952	29.4	C	2.5	1.62			ML4	5.153	31%
19	**01398000**	**Neshanic River @ Reaville**	1930-1962	25.7	A	0.3	0.19	1.55	0.12	ML6	1.43	14%
20	**01409500**	**Batsto River @ Batsto**	1927-2005	67.8	B	9.5	6.14	43.95	26.14	ML9	17.81	34%
21	**01467000**	**N. Branch Rancocas near Pemberton**	1921-2005	118	B	10	6.46	53	22.3	ML3	30.7	21%
22	**01399500**	**(2) Lamington River near Pottersville**	1921-1950	32.8	C	2.875	1.86			ML4	7.7	24%
23	**01396660**	**(3) Mulhockaway Creek @ Van Syckel**	1977-2005	11.8	C	0.6	0.39			ML7	1.9	20%
24	**01386000**	**West Brook near Wanaque**	1934-1978	11.8	C	0.45	0.29	1.94	0.38	ML6/FL1	1.56	19%
											Average =	**23%**

Notes

(1) - From area ratio of Whippany River HUC11 02030103020 LFM Analysis (69.9 mi^2 and 12.2 LFM)
(2) - From area ratio of downstream gage 01399780 flow stats (99 mi^2 and 23.2 LFM)
(3) - From area ratio of downstream gage 01396700 flow stats (20.5 mi^2 and 3.26 LFM)
DL1: Annual minimum daily flow. (cfs)
DL4: Annual Minimum of 30-day moving average flow. (cfs)
ML3: Mean or median (user choice) of March of minimum flow values. Determine the minimum flow for each March over the entire flow record. (cfs)
ML4: Mean or median (user choice) of April of minimum flow values. Determine the minimum flow for each April over the entire flow record. (cfs)
ML5: Mean or median (user choice) of May of minimum flow values. Determine the minimum flow for each May over the entire flow record. (cfs)
ML6: Mean or median (user choice) of June of minimum flow values. Determine the minimum flow for each June over the entire flow record. (cfs)
ML7: Mean or median (user choice) of July of minimum flow values. Determine the minimum flow for each July over the entire flow record. (cfs)
ML8: Mean or median (user choice) of August of minimum flow values. Determine the minimum flow for each August over the entire flow record. (cfs)
ML9: Mean or median (user choice) of September of minimum flow values. Determine the minimum flow for each September over the entire flow record. (cfs)
FH3: High Flood pulse count. (number of days/year)
FH10: Flood frequency. (number of events/year)

ID	Gage Number	Name	Baseline Period	Drainage Area (mi^2)	Stream Type Classification	Stream Flow Reduction (CFS)	Stream Flow Reduction (mgd)	* September Median (mgd)	* 7Q10 (mgd)	Stream Stat Violation	LFM Difference of 7Q10 and September Median (mgd)	** Percent of LFM

FL1: Low flood pulse count. (number of events/year)

*September Median and 7Q10 Flows were obtained from New Jersey Geological Survey Technical Memorandum 13-3, Domber, S., Snook, I., Hoffman, J.L., 2013, "Using the Stream Low Flow Margin Method to Assess Water Availability in New Jersey's Water-Table-Aquifer Systems."
**The "Percentages" column is the Stream Flow Reduction divided by the "Difference of 7Q10 and September Median".

To identify potential water-availability shortages, the net volume of water lost to depletive and consumptive water uses (see Net Dep-Con columns in B tables) and the volume of water still available for additional depletive and consumptive loss (known as Remaining Available Water) are calculated for each HUC11. To calculate net consumptive and depletive loss, a three-year running average of individual years was calculated for each HUC11. The largest three-year running average value was utilized for each HUC11. Loss calculations consider both current and full allocation water use rates and loss from eight different water use groups (power generation, public supply, agriculture, irrigation, industrial, commercial, mining, and unclassified). Remaining Available Water (RAW) is the difference between the amount of water available at the 25% threshold and calculated net depletive and consumptive losses for each HUC11. HUC11s with potential water availability shortages have a RAW value of 0.

The LFM method is one screening tool used to identify watersheds with potential water availability shortages but is not intended to replace other more rigorous and data-intensive methods for examining water availability. The LFM method does not account for limitations of available water due to water quality or existing regulatory programs, and the method is periodically updated as new water use data and information become available.

WATERSHED MANAGEMENT AREA 01

UPPER DELAWARE

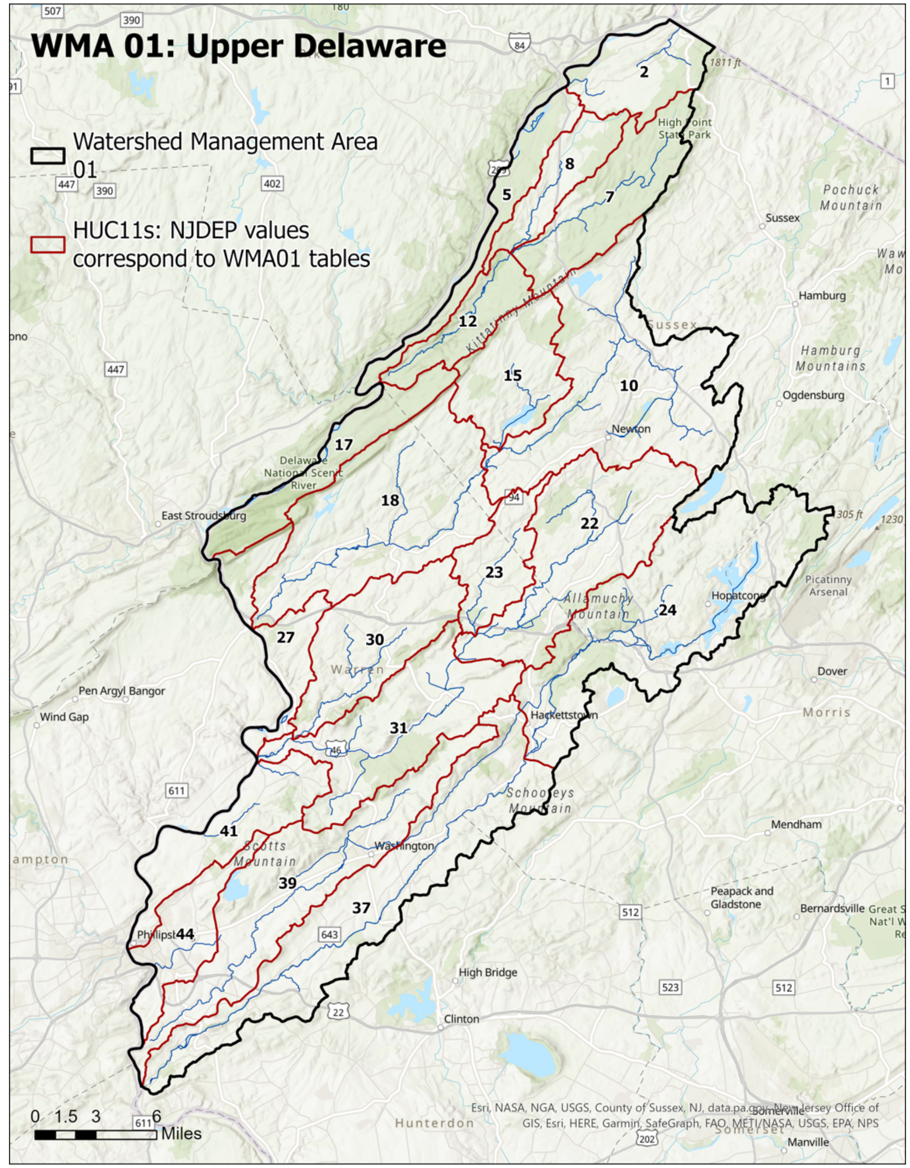

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Table 1A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
2	**02040104090**	Shimers Brook / Clove Brook	22.8	22.1	5.7	1.7	25%	3.9			Yes			0	
5	**02040104110**	Walpack Bend / Montague Riverfront	18.0	16.1	3.3	0.9	25%	2.5			Yes			0	
8	**02040104130**	Little Flat Brook	16.8	16.8	3.1	0.8	25%	2.3			Yes			0	
7	**02040104140**	Big Flat Brook	32.6	32.6	5.9	1.6	25%	4.3			Yes			0	
12	**02040104150**	Flat Brook	16.9	66.2	4.9	2.5	25%	2.4						0	
17	**02040104240**	Van Campens Brook / Dunnfield Creek	23.3	22.1	4.9	1.2	25%	3.6			Yes			0	
15	**02040105030**	Trout Brook / Swartswood Lake	27.8	27.8	4.7	0.8	25%	3.9			Yes			0	
10	**02040105040**	Paulins Kill (above Stillwater Village)	79.4	107.1	23.6	8.3	25%	15.2	Partial					0	
18	**02040105050**	Paulins Kill (below Stillwater Village)	69.8	176.8	18.6	5.0	25%	13.6	Partial		Yes			0	
27	**02040105060**	Stony Brook / Delawanna Creek	19.7	18.7	3.9	1.0	25%	3.0	Partial		Yes			0	
22	**02040105070**	Pequest River (above/incl Bear Swamp)	54.7	72.9	12.6	2.8	25%	9.8	Partial		Yes			0	

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi²)	Watershed Area (mi²)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
23	**02040105080**	Bear Creek	18.3	18.3	4.0	1.0	25%	3.0	Partial		Yes			0	
31	**02040105090**	Pequest River (below Bear Swamp)	47.4	157.0	9.7	2.5	25%	7.2	All		Yes			4	
30	**02040105100**	Beaver Brook	36.7	36.7	5.9	1.5	25%	4.5	Partial		Yes			0	
41	**02040105110**	Pophandusing Brook / Buckhorn Creek	28.2	27.6	5.4	1.5	25%	3.9	All		Yes			0	
44	**02040105120**	Lopatcong Creek	19.8	19.5	6.3	3.0	25%	3.4	All					0	
39	**02040105140**	Pohatcong Creek	58.1	58.0	13.6	4.2	25%	9.4	All		Yes			0	
24	**02040105150**	Musconetcong River (above Trout Brook)	81.6	81.6	13.7	3.2	25%	10.5	All		Yes			0	
37	**02040105160**	Musconetcong River (below incl Trout Bk)	73.9	155.5	19.9	5.9	25%	14.0	All		Yes			0	

Table 1B. Summary of HUC11 Remaining Available Water and Full Allocation

					Current			Full Allocation			Largest Dep-Con Loss			
DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Current Largest Loss	Current Largest Loss % Available Water	Full Allocation Largest Loss	Full Allocation Largest Loss % Available Water
2	**02040104090**	Shimers Brook / Clove Brook	2014	1.0	0.2	19%	0.8	0.4	41%	0.6	Potable	17%	Potable	50%
5	**02040104110**	Walpack Bend / Montague Riverfront	2013	0.6	0.0	2%	0.6	0.0	0%	0.6	Potable	2%	Potable	N/A

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DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Current			Full Allocation			Largest Dep-Con Loss			
					Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Current Largest Loss	Current Largest Loss % Available Water	Full Allocation Largest Loss	Full Allocation Largest Loss % Available Water
8	**02040104130**	Little Flat Brook	2013	0.6	0.0	5%	0.5	0.0	9%	0.5	Potable	5%	Potable	N/A
7	**02040104140**	Big Flat Brook	2014	1.1	0.0	0%	1.1	0.0	0%	1.1	Minimal Loss	0%	Potable	N/A
12	**02040104150**	Flat Brook	2015	0.6	0.0	0%	0.6	0.0	0%	0.6	Potable	0%	Potable	N/A
17	**02040104240**	Van Campens Brook / Dunnfield Creek	2013	0.9	0.0	2%	0.9	0.0	3%	0.9	Potable	2%	Potable	N/A
15	**02040105030**	Trout Brook / Swartswood Lake	2020	1.0	0.1	5%	0.9	0.1	9%	0.9	Potable	5%	Potable	N/A
10	**02040105040**	Paulins Kill (above Stillwater Village)	2017	3.8	1.6	42%	2.2	5.9	156%	0.0	Potable	21%	Potable	100%
18	**02040105050**	Paulins Kill (below Stillwater Village)	2014	3.4	0.2	5%	3.2	0.9	26%	2.5	Potable	4%	Potable	23%
27	**02040105060**	Stony Brook / Delawanna Creek	2016	0.7	0.0	2%	0.7	0.1	12%	0.6	Potable	2%	Ag/Irr	12%
22	**02040105070**	Pequest River (above/incl Bear Swamp)	2015	2.5	1.2	48%	1.3	3.3	136%	0.0	Potable	24%	Potable	87%
23	**02040105080**	Bear Creek	2020	0.7	0.0	2%	0.7	0.1	18%	0.6	Potable	2%	Potable	18%
31	**02040105090**	Pequest River (below Bear Swamp)	2013	1.8	2.4	135%	0.0	5.7	317%	0.0	Potable	100%	Potable	100%
30	**02040105100**	Beaver Brook	2014	1.1	0.1	7%	1.0	0.9	84%	0.2	Potable	5%	Ag/Irr	51%
41	**02040105110**	Pophandusing Brook / Buckhorn Creek	2014	1.0	0.3	30%	0.7	0.9	93%	0.1	Potable	28%	Potable	67%
44	**02040105120**	Lopatcong Creek	2018	0.8	-1.9	Net Gain	2.7	-1.5	Net Gain	2.4	Com/Ind /Min	21%	Com/Ind/ Min	35%

DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Current			Full Allocation			Largest Dep-Con Loss			
					Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Current Largest Loss	Current Largest Loss % Available Water	Full Allocation Largest Loss	Full Allocation Largest Loss % Available Water
39	**02040105140**	Pohatcong Creek	2014	2.3	0.5	20%	1.9	1.8	75%	0.6	Potable	19%	Potable	50%
24	**02040105150**	Musconetcong River (above Trout Brook)	2014	2.6	1.7	64%	0.9	6.6	253%	0.0	Potable	61%	Potable	100%
37	**02040105160**	Musconetcong River (below incl Trout Bk)	2020	3.5	0.2	7%	3.3	2.6	74%	0.9	Non-Ag Irr	6%	Potable	47%

Table 1C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
2	**02040104090**	Shimers Brook / Clove Brook	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.4	0.0
5	**02040104110**	Walpack Bend / Montague Riverfront	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	**02040104130**	Little Flat Brook	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0
7	**02040104140**	Big Flat Brook	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	**02040104150**	Flat Brook	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	**02040104240**	Van Campens Brook /Dunnfield Creek	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0
15	**02040105030**	Trout Brook / Swartswood Lake	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.3	0.0
10	**02040105040**	Paulins Kill (above Stillwater Village)	1.5	0.0	1.1	0.0	6.4	0.0	0.0	0.1	0.1	0.0	0.0	2.4	6.5	0.0	9.0	0.0

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/ Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
18	**02040105050**	Paulins Kill (below Stillwater Village)	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.7	0.0
27	**02040105060**	Stony Brook / Delawanna Creek	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	142.4	0.3	142.4	0.0	142.7	1.1
22	**02040105070**	Pequest River (above/incl Bear Swamp)	0.8	0.0	1.0	0.0	0.0	0.5	0.1	0.0	0.1	0.0	0.0	2.0	0.2	0.0	2.2	0.0
23	**02040105080**	Bear Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	**02040105090**	Pequest River (below Bear Swamp)	3.1	0.0	0.7	0.4	0.0	6.2	0.1	0.0	0.0	0.0	0.0	9.3	0.1	0.0	9.4	0.0
30	**02040105100**	Beaver Brook	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.3	0.0
41	**02040105110**	Pophandusing Brook /Buckhorn Creek	0.6	0.0	0.2	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	1.9	3.4
44	**02040105120**	Lopatcong Creek	0.2	0.0	0.2	0.1	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.9	0.0	2.3	0.0
39	**02040105140**	Pohatcong Creek	1.1	0.0	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	1.6	0.0
24	**02040105150**	Musconetcong River (above Trout Brook)	3.7	0.0	1.7	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	4.9	0.3	0.0	5.3	0.0
37	**02040105160**	Musconetcong River (below incl Trout Bk)	1.9	0.0	1.0	0.2	0.0	0.0	0.0	0.2	0.1	0.0	0.0	3.0	0.1	0.0	3.2	0.0

Table 1D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
2	**02040104090**	Shimers Brook / Clove Brook	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2
5	**02040104110**	Walpack Bend / Montague Riverfront	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	**02040104130**	Little Flat Brook	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
7	**02040104140**	Big Flat Brook	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
12	02040104150	Flat Brook	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	02040104240	Van Campens Brook / Dunnfield Creek	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
15	02040105030	Trout Brook / Swartswood Lake	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2
10	02040105040	Paulins Kill (above Stillwater Village)	0.0	0.7	0.0	0.8	0.0	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.9	6.5	7.4
18	02040105050	Paulins Kill (below Stillwater Village)	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5
27	02040105060	Stony Brook / Delawanna Creek	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	142.4	0.3	142.4	142.7
22	02040105070	Pequest River (above/incl Bear Swamp)	0.0	0.2	0.0	0.7	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.8	0.3	1.0
23	02040105080	Bear Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	02040105090	Pequest River (below Bear Swamp)	0.0	0.4	0.0	0.5	0.3	0.0	5.8	0.0	0.0	0.0	0.0	0.0	6.7	0.4	7.0
30	02040105100	Beaver Brook	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2
41	02040105110	Pophandusing Brook / Buckhorn Creek	0.0	0.3	0.0	0.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.3	1.6
44	02040105120	Lopatcong Creek	0.0	2.3	0.0	0.1	0.1	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.2	3.9	4.1
39	02040105140	Pohatcong Creek	0.0	0.6	0.0	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6	1.2
24	02040105150	Musconetcong River (above Trout Brook)	0.1	2.0	0.0	1.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	1.3	2.3	3.6
37	02040105160	Musconetcong River (below incl Trout Bk)	0.0	2.0	0.0	0.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	2.9

Notes (applicability may vary by WMA)

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.
3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.
4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.

5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

WATERSHED MANAGEMENT AREA 02

WALLKILL

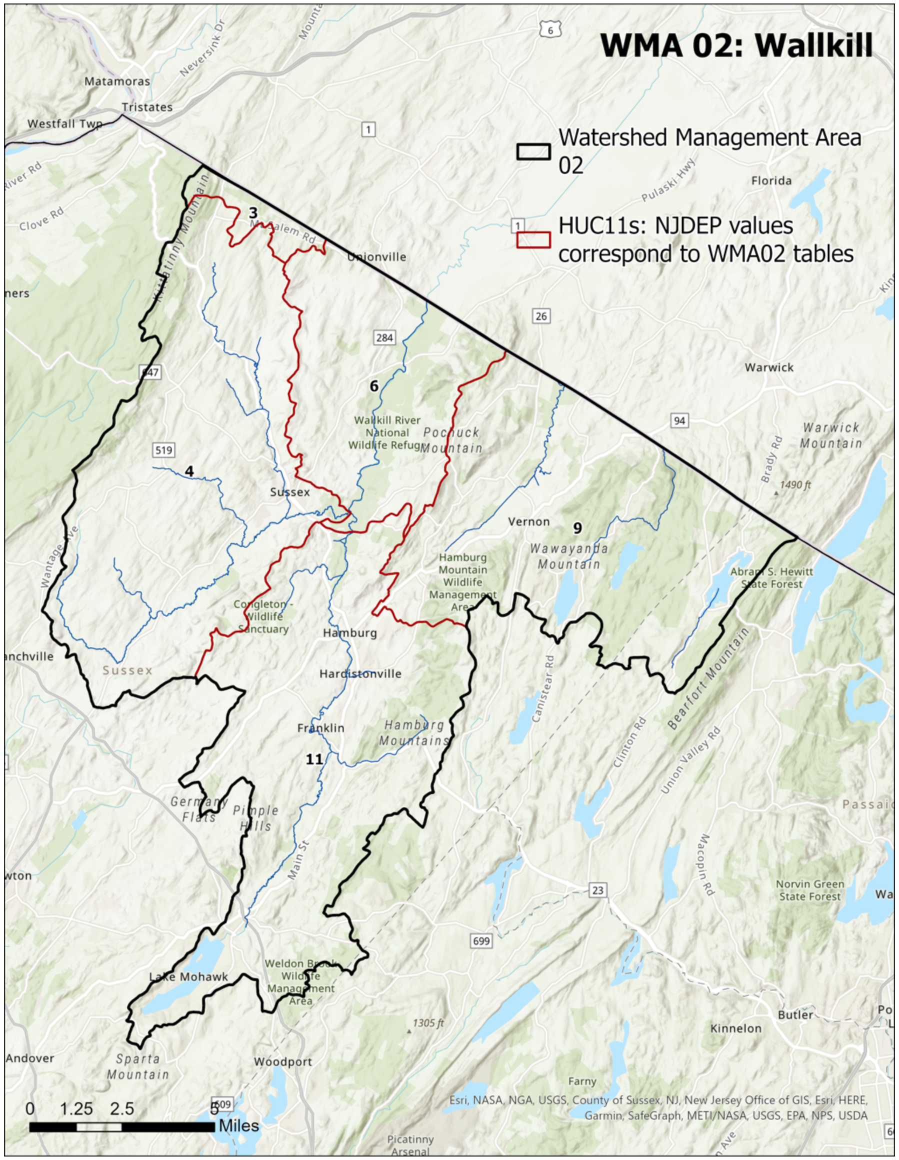

Table 2A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
3	**02020007000**	Rutgers Creek tribs	3.2	3.2	Not Calc.	Not Calc.	25%	0.3						0	
11	**02020007010**	Wallkill River (above road to Martins)	61.0	61.0	11.1	2.7	25%	8.4	Partial		Yes			0	
4	**02020007020**	Papakating Creek	60.6	60.6	6.2	1.2	25%	5.0			Yes			0	
6	**02020007030**	Wallkill River (below road to Martins)	29.2	153.7	3.8	0.8	25%	3.0	Partial		Yes			0	
9	**02020007040**	Pochuck Creek	54.3	106.1	10.7	2.6	25%	8.1	All		Yes			0	

Table 2B. Summary of HUC11 Remaining Available Water and Full Allocation

					Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
3	**02020007000**	Rutgers Creek tribs												
11	**02020007010**	Wallkill River (above road to Martins)	2016	2.1	1.2	57%	0.9	2.5	116%	0.0	Potable	31%	Potable	90%
4	**02020007020**	Papakating Creek	2013	1.2	0.4	29%	0.9	1.4	111%	0.0	Potable	24%	Potable	100%
6	**02020007030**	Wallkill River (below road to Martins)	2014	0.7	0.1	15%	0.6	0.8	103%	0.0	Potable	15%	Potable	100%

DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
					Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
9	**02020007040**	Pochuck Creek	2017	2.0	1.0	49%	1.0	3.3	161%	0.0	Potable	49%	Potable	100%

Table 2C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
3	**02020007000**	Rutgers Creek tribs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	**02020007010**	Wallkill River (above road to Martins)	1.9	0.0	0.6	0.2	0.1	0.0	0.0	0.3	0.3	0.0	0.0	2.7	0.4	0.0	3.0	0.7
4	**02020007020**	Papakating Creek	0.0	0.2	0.7	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.6	0.3	0.0	0.9	0.0
6	**02020007030**	Wallkill River (below road to Martins)	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.6	0.0
9	**02020007040**	Pochuck Creek	0.9	0.0	1.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	2.1	0.0

Table 2D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
3	**02020007000**	Rutgers Creek tribs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	**02020007010**	Wallkill River (above road to Martins)	0.0	1.1	0.0	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.2	1.8
4	**02020007020**	Papakating Creek	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5
6	**02020007030**	Wallkill River (below road to Martins)	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4
9	**02020007040**	Pochuck Creek	0.0	0.0	0.0	0.9	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	1.1

Notes (applicability may vary by WMA)

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.
3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.
4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.
5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

WATERSHED MANAGEMENT AREA 03

POMPTON, PEQUANNOCK, WANAQUE, AND RAMAPO[1]

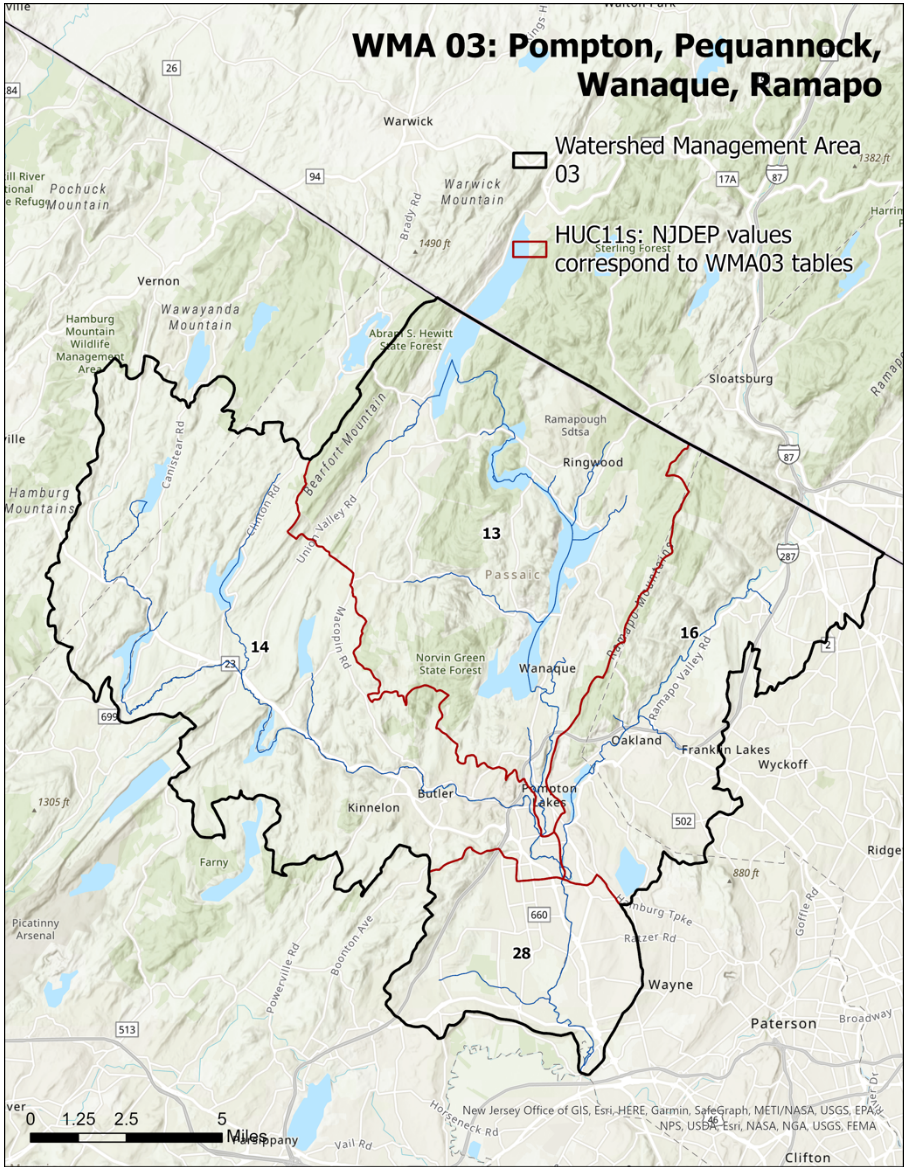

Table 3A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi²)	Watershed Area (mi²)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
14	**02030103050**	Pequannock River	86.8	193.6	18.4	4.9	25%	13.5	All	Yes	Yes			0	
13	**02030103070**	Wanaque River	79.2	106.8	14.9	3.7	25%	11.2	All	Yes	Yes			0	
16	**02030103100**	Ramapo River	47.8	161.0	8.0	3.0	25%	5.0	Partial	Yes				8	
28	**02030103110**	Pompton River	24.0	378.6	4.6	0.9	25%	3.7	Partial	Yes	Yes	Yes		0	

Table 3B. Summary of HUC11 Remaining Available Water and Full Allocation

					Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
14	**02030103050**	Pequannock River	2013	3.4	2.0	58%	1.4	3.1	91%	0.3	Potable	58%	Potable	91%
13	**02030103070**	Wanaque River	2015	2.8	1.7	62%	1.1	3.6	128%	0.0	Potable	62%	Potable	100%
16	**02030103100**	Ramapo River	2014	1.3	5.8	465%	0.0	6.5	515%	0.0	Potable	100%	Potable	100%
28	**02030103110**	Pompton River	2016	0.9	-1.4	Net Gain	2.3	1.1	114%	0.0	Non-Ag Irr	19%	Potable	43%

Table 3C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
14	**02030103050**	Pequannock River	2.1	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0	2.9	31.5
13	**02030103070**	Wanaque River	2.8	0.0	1.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.1	0.0	3.7	114.0
16	**02030103100**	Ramapo River	7.2	0.0	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	0.0	0.0	7.3	0.0

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/ Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
28	**02030103110**	Pompton River	2.9	0.0	0.3	0.0	0.8	0.0	0.1	0.2	0.0	0.0	0.0	3.0	0.9	0.0	4.0	83.5

Table 3D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
14	**02030103050**	Pequannock River	0.0	0.1	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.1	1.0
13	**02030103070**	Wanaque River	0.0	0.9	0.0	0.8	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	2.0
16	**02030103100**	Ramapo River	0.0	0.8	0.0	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.8	1.4
28	**02030103110**	Pompton River	0.0	4.3	0.0	0.2	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.2	5.1	5.3

Notes (applicability may vary by WMA)

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.
3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.
4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.
5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

WATERSHED MANAGEMENT AREA 04

LOWER PASSAIC AND SADDLE[1]

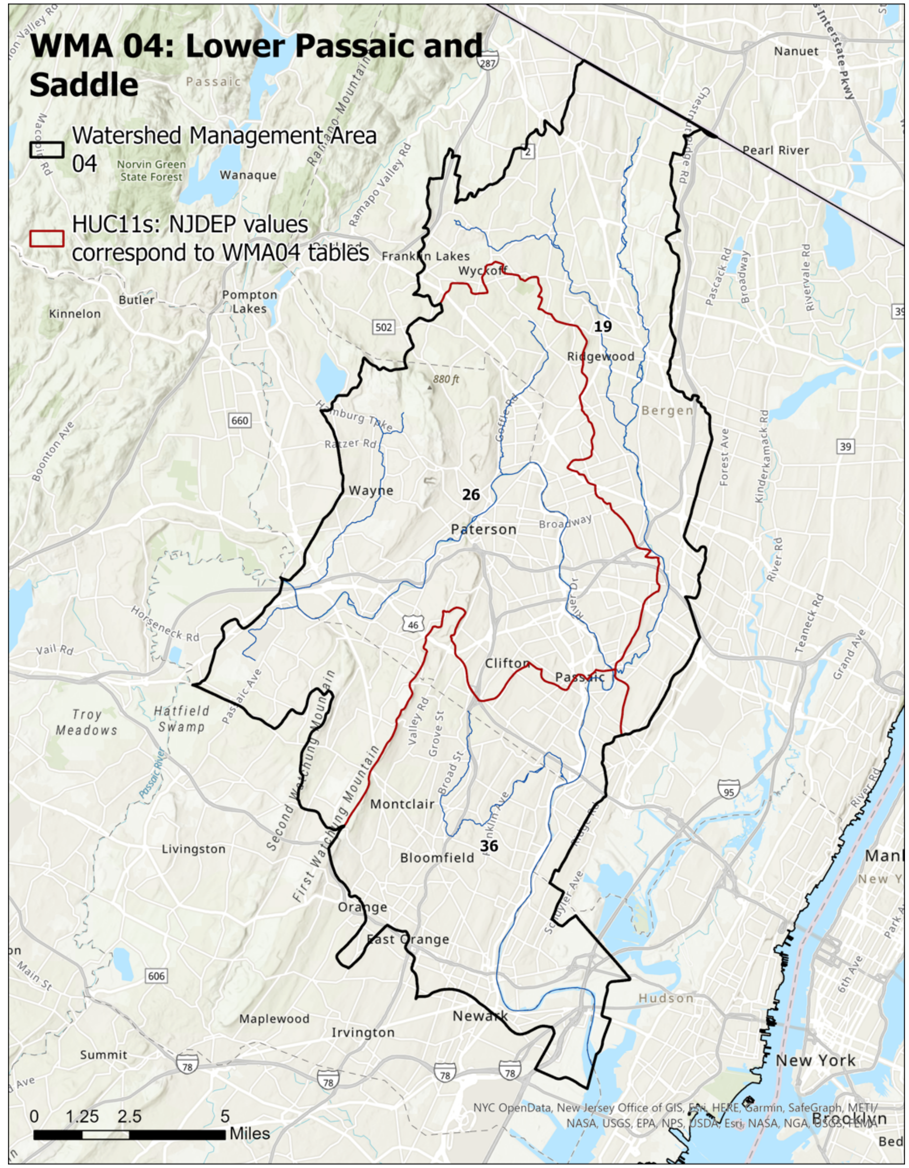

Table 4A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
26	**02030103120**	Passaic River Lower (Saddle to Pompton)	83.4	823.3	16.3	6.0	25%	10.3		Yes		Yes		4	
19	**02030103140**	Saddle River	51.5	59.5	28.7	13.7	25%	15.0	Partial	Yes				0	
36	**02030103150**	Passaic River Lower (Nwk Bay to Saddle)	53.6	936.3	22.5	11.9	25%	10.5				Yes		0	Yes

Table 4B. Summary of HUC11 Remaining Available Water and Full Allocation

					Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
DEP Value	**HUC11**	**HUC11 Name**	**Peak Year With.[5]**	**Available Water (mgd)**	**Net Dep-Con (mgd)**	**% Available Used**	**Remaining Available Water (mgd)**	**Net Dep-Con (mgd)**	**% Available Used**	**Remaining Available Water (mgd)**	**Largest Loss Current Use**	**Largest Loss % Available Water (Current)**	**Largest Loss F.A. Use**	**Largest Loss % Available Water (F.A.)**
26	**02030103120**	Passaic River Lower (Saddle to Pompton)	2015	2.6	4.9	190%	0.0	30.1	1,164%	0.0	Potable	100%	Pow Gen	100%
19	**02030103140**	Saddle River	2015	3.7	0.0	0%	3.7	8.2	218%	0.0	Non-Ag Irr	16%	Potable	100%
36	**02030103150**	Passaic River Lower (Nwk Bay to Saddle)	2013	2.6	2.2	84%	0.4	4.7	180%	0.0	Potable	73%	Potable	100%

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Table 4C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
26	**02030103120**	Passaic River Lower (Saddle to Pompton)	12.8	0.0	0.8	0.9	1.9	0.1	0.0	0.4	0.2	0.0	0.0	13.5	2.2	0.0	15.6	70.9
19	**02030103140**	Saddle River	9.2	0.0	1.2	0.2	1.2	0.1	0.0	0.7	0.1	0.0	0.0	10.3	1.3	0.0	11.5	1.1
36	**02030103150**	Passaic River Lower (Nwk Bay to Saddle)	2.1	0.0	0.1	0.3	0.0	0.0	0.0	0.2	0.2	0.0	0.0	2.4	0.2	0.0	2.6	0.0

Table 4D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
26	**02030103120**	Passaic River Lower (Saddle to Pompton)	0.0	7.5	0.0	0.6	0.8	1.7	0.0	0.0	0.0	0.0	0.0	0.0	1.4	9.3	10.7
19	**02030103140**	Saddle River	0.0	9.2	0.0	0.9	0.2	1.1	0.1	0.0	0.1	0.0	0.0	0.0	1.2	10.3	11.5
36	**02030103150**	Passaic River Lower (Nwk Bay to Saddle)	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4

Notes (applicability may vary by WMA)

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.
3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.
4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.
5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

WATERSHED MANAGEMENT AREA 05

HACKENSACK, HUDSON, AND PASCACK[1]

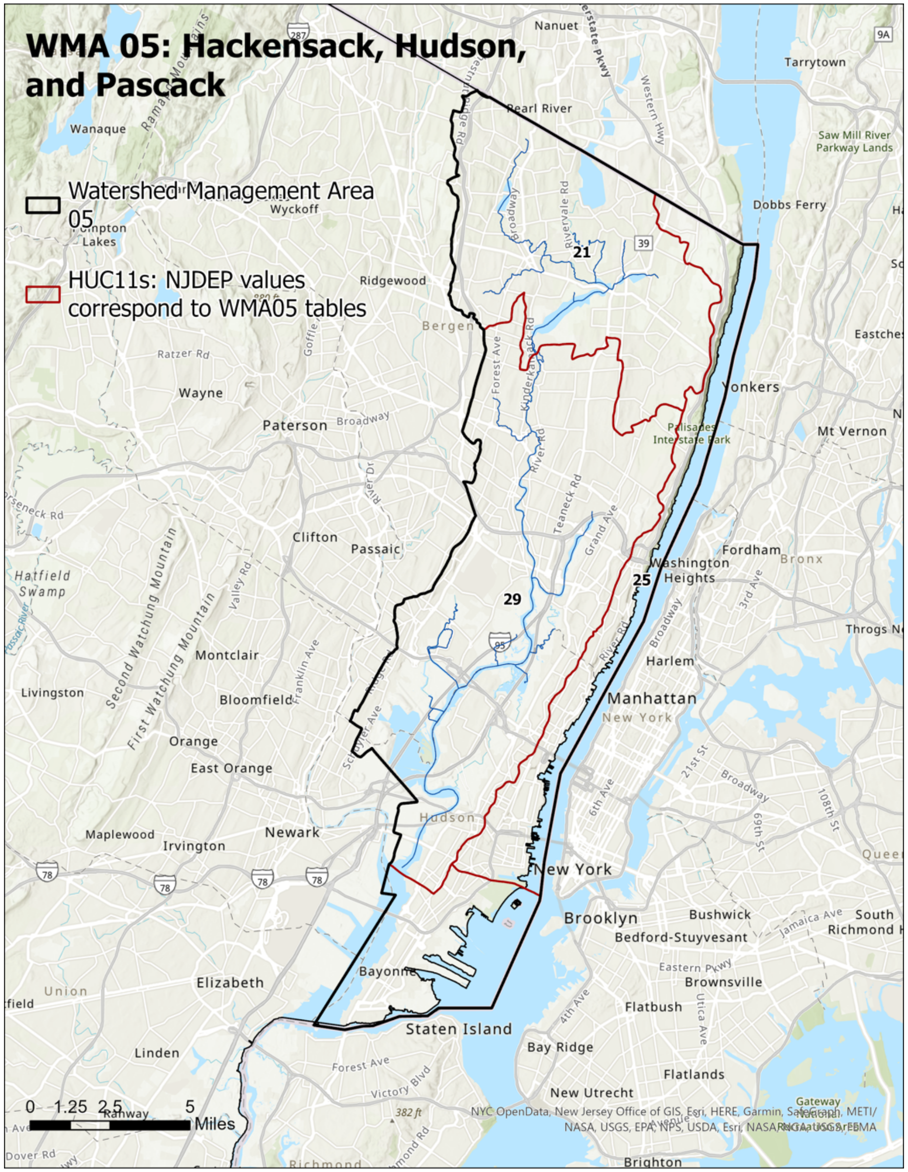

Table 5A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
25	**02030101170**	Hudson River	29.1	44.4	8.3	4.1	25%	4.2						0	Yes
21	**02030103170**	Hackensack R (above Hirshfeld Brook)	50.9	112.4	20.8	11.7	25%	9.0		Yes				8	
29	**02030103180**	Hackensack R (below/incl Hirshfeld Bk)	85.1	197.4	19.1	9.1	25%	10.0		Yes		Yes		0	Yes

Table 5B. Summary of HUC11 Remaining Available Water and Full Allocation

					Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
25	**02030101170**	Hudson River	2019	1.0	0.0	4%	1.0	0.1	8%	1.0	Non-Ag Irr	3%	Potable	6%
21	**02030103170**	Hackensack R (above Hirshfeld Brook)	2017	2.3	4.0	177%	0.0	6.4	283%	0.0	Potable	100%	Potable	100%
29	**02030103180**	Hackensack R (below/incl Hirshfeld Bk)	2015	2.5	-1.9	Net Gain	4.4	-1.4	Net Gain	3.9	Non-Ag Irr	11%	Non-Ag Irr	31%

Table 5C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
25	**02030101170**	Hudson River	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0
21	**02030103170**	Hackensack R (above Hirshfeld Brook)	4.2	0.0	0.5	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	4.4	0.1	0.0	4.5	100.1
29	**02030103180**	Hackensack R (below/incl Hirshfeld Bk)	0.3	0.0	0.1	0.5	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.9	0.1	0.0	1.1	1.3

Table 5D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
25	**02030101170**	Hudson River	0.0	0.0	26.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
21	**02030103170**	Hackensack R (above Hirshfeld Brook)	0.0	0.0	0.0	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5
29	**02030103180**	Hackensack R (below/ incl Hirshfeld Bk)	0.0	2.5	56.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.5	3.0

Notes (applicability may vary by WMA)

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.
3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.
4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.

5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

WATERSHED MANAGEMENT AREA 06

UPPER AND MIDDLE PASSAIC, WHIPPANY, AND ROCKAWAY

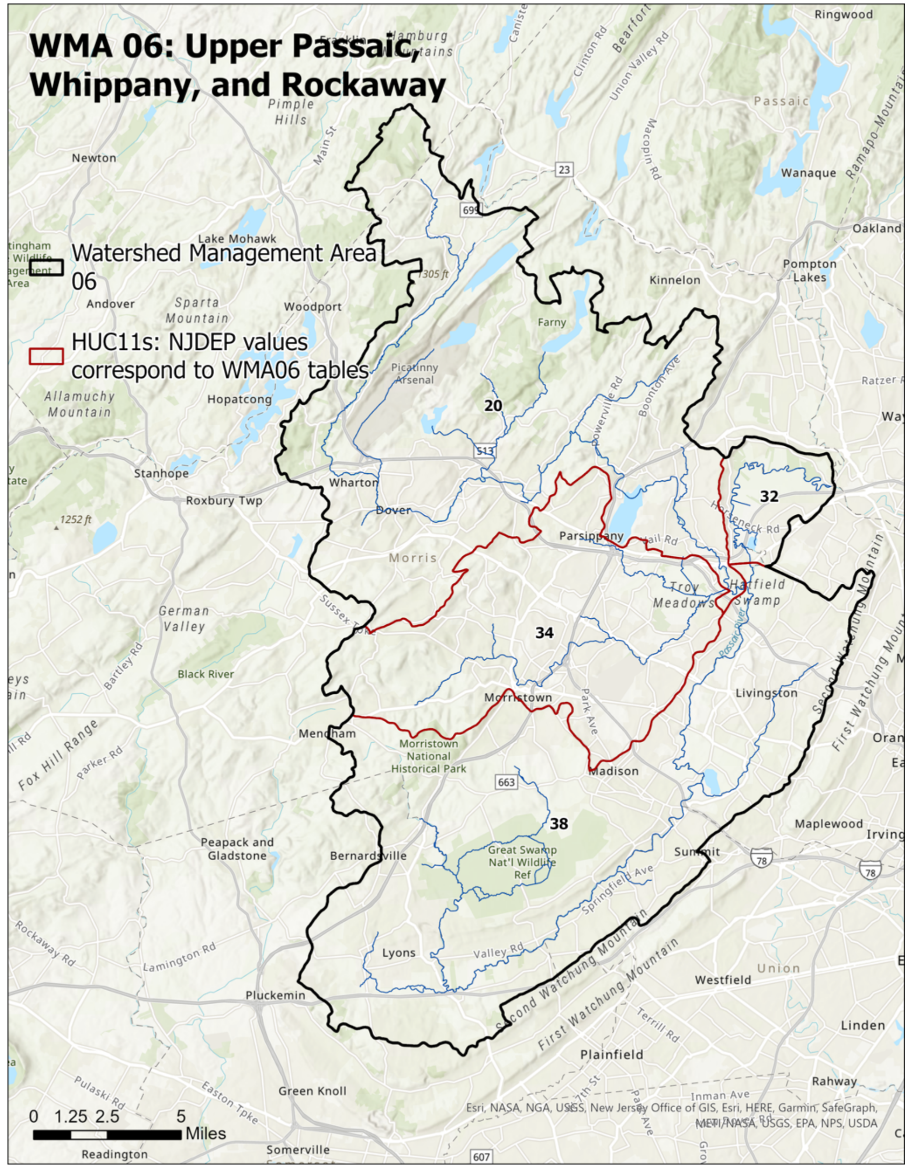

Table 6A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi²)	Watershed Area (mi²)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
38	**02030103010**	Passaic River Upr (above Pine Bk br)	143.2	349.4	29.7	7.1	25%	22.7	Partial	Yes	Yes	Yes	Yes	5	
34	**02030103020**	Whippany River	69.6	69.6	17.8	5.6	25%	12.2	Partial	Yes	Yes		Yes	8	
20	**02030103030**	Rockaway River	136.8	206.3	30.4	7.9	25%	22.5	All	Yes	Yes		Yes	0	
32	**02030103040**	Passaic River Upr (Pompton to Pine Bk)	11.9	361.3	2.7	0.7	25%	2.0	Partial	Yes	Yes	Yes	Yes	0	

Table 6B. Summary of HUC11 Remaining Available Water and Full Allocation

					Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
38	**02030103010**	Passaic River Upr (above Pine Bk br)	2017	5.7	8.4	147%	0.0	22.7	400%	0.0	Potable	100%	Potable	100%
34	**02030103020**	Whippany River	2017	3.0	12.2	402%	0.0	14.7	483%	0.0	Potable	100%	Potable	100%
20	**02030103030**	Rockaway River	2016	5.6	-4.6	Net Gain	10.2	3.3	59%	2.3	Non-Ag Irr	4%	Potable	24%
32	**02030103040**	Passaic River Upr (Pompton to Pine Bk)	2013	0.5	0.1	21%	0.4	0.3	52%	0.2	Potable	18%	Potable	27%

Table 6C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/ Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
38	**02030103010**	Passaic River Upr (above Pine Bk br)	22.7	0.0	1.0	0.5	0.0	0.0	0.0	0.4	0.5	0.0	0.0	22.2	0.5	0.0	22.7	0.0
34	**02030103020**	Whippany River	17.9	0.0	0.3	0.7	0.0	0.0	0.0	0.1	0.1	0.0	0.0	17.1	0.1	0.0	17.2	2.1
20	**02030103030**	Rockaway River	10.2	0.8	2.0	0.3	0.1	0.0	0.0	0.1	0.2	0.0	0.0	11.4	1.0	0.0	12.4	48.3
32	**02030103040**	Passaic River Upr (Pompton to Pine Bk)	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0

Table 6D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
38	**02030103010**	Passaic River Upr (above Pine Bk br)	0.0	13.0	0.0	0.7	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	13.1	14.3
34	**02030103020**	Whippany River	0.0	4.1	0.0	0.2	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	4.1	4.9
20	**02030103030**	Rockaway River	0.0	15.1	0.0	1.5	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.8	15.2	17.0
32	**02030103040**	Passaic River Upr (Pompton to Pine Bk)	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1

Notes (applicability may vary by WMA)

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.
3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.

4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.
5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

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WATERSHED MANAGEMENT AREA 07

ARTHUR KILL

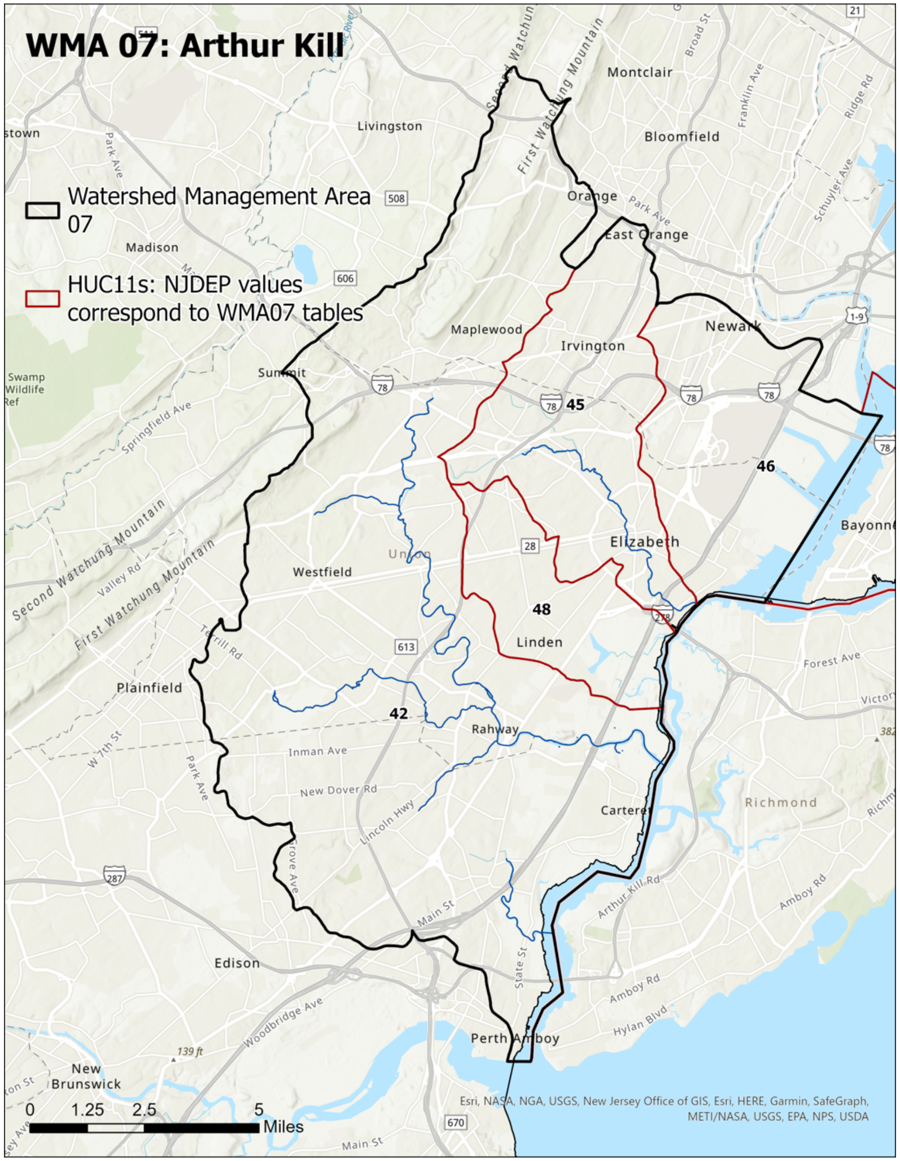

Table 7A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
46	**02030104010**	Newark Bay / Kill Van Kull / Upr NY Bay	43.6	967.0	Not Calc.	Not Calc.	25%	8.7				Yes	Yes	0	Yes
45	**02030104020**	Elizabeth River	22.9	42.8	10.4	5.7	25%	4.7					Yes	5	Yes
48	**02030104030**	Morses Creek / Piles Creek	12.0	11.8	2.6	1.2	25%	1.4					Yes	0	
42	**02030104050**	Rahway River / Woodbridge Creek	101.1	99.2	16.2	6.7	25%	9.5					Yes	8	Yes

Table 7B. Summary of HUC11 Remaining Available Water and Full Allocation

					Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
46	**02030104010**	Newark Bay / Kill Van Kull / Upr NY Bay												
45	**02030104020**	Elizabeth River	2013	1.2	2.4	204%	0.0	3.0	258%	0.0	Potable	100%	Potable	100%
48	**02030104030**	Morses Creek / Piles Creek	2013	0.3	0.0	14%	0.3	0.0	Net Gain	0.4	Non-Ag Irr	13%	Com/Ind/ Min	0%
42	**02030104050**	Rahway River / Woodbridge Creek	2014	2.4	14.6	610%	0.0	29.8	1250%	0.0	Potable	100%	Potable	100%

Table 7C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/ Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
46	**02030104010**	Newark Bay / Kill Van Kull / Upr NY Bay	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.4	0.1	0.0	0.5	0.0
45	**02030104020**	Elizabeth River	2.6	0.0	0.0	0.3	0.0	0.0	0.0	0.1	0.0	0.0	0.0	2.7	0.0	0.0	2.7	0.0
48	**02030104030**	Morses Creek / Piles Creek	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.1	0.0	0.0	3.1	1.1	3.1	0.0	4.2	0.0
42	**02030104050**	Rahway River / Woodbridge Creek	9.5	5.1	0.2	0.5	0.0	0.0	0.0	0.7	0.3	0.0	0.0	9.9	5.5	0.0	15.3	0.0

Table 7D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
46	**02030104010**	Newark Bay / Kill Van Kull / Upr NY Bay	0.0	0.0	217.2	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4
45	**02030104020**	Elizabeth River	0.0	0.0	54.8	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3
48	**02030104030**	Morses Creek / Piles Creek	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	1.0	3.1	4.2
42	**02030104050**	Rahway River / Woodbridge Creek	0.0	0.0	31.2	0.2	0.5	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.7	0.0	0.8

<u>Notes (applicability may vary by WMA)</u>

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.

3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.
4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.
5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

WATERSHED MANAGEMENT AREA 08

NORTH AND SOUTH BRANCH RARITAN

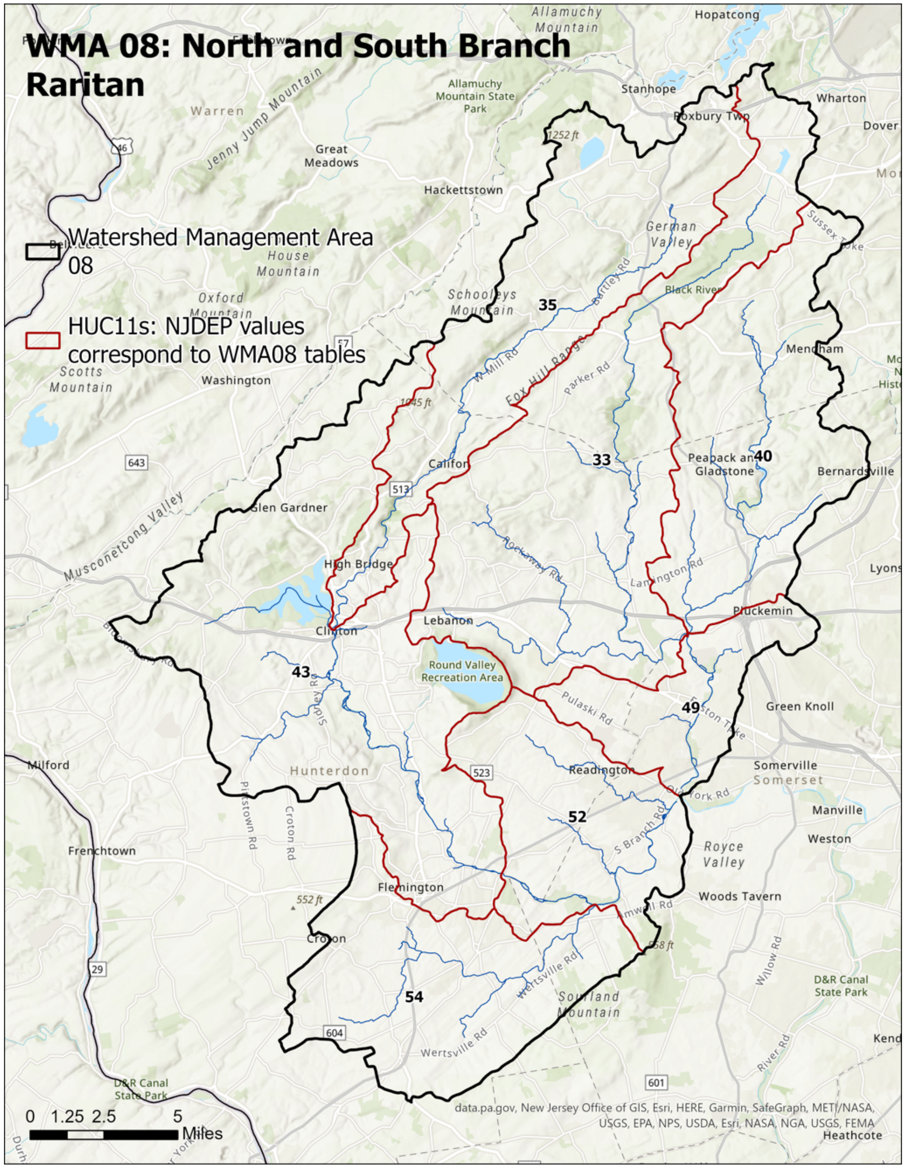

Table 8A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
35	**02030105010**	Raritan River SB (above Spruce Run)	71.0	70.9	24.1	8.3	25%	15.7	All	Yes				8	
43	**02030105020**	Raritan River SB (3 Brdgs to Spruce Run)	111.0	181.8	26.4	8.3	25%	18.1	Partial	Yes	Yes	Yes		0	
54	**02030105030**	Neshanic River	55.7	55.7	3.4	0.3	25%	3.1		Yes	Yes			4	
52	**02030105040**	Raritan River SB (NB to Three Bridges)	41.8	279.3	8.0	1.8	25%	6.1	Partial	Yes	Yes	Yes		0	
33	**02030105050**	Lamington River	99.3	99.2	32.7	9.5	25%	23.2	Partial	Yes	Yes			0	
40	**02030105060**	Raritan River NB (above Lamington)	64.0	63.9	19.6	5.4	25%	14.3	All	Yes	Yes			0	
49	**02030105070**	Raritan River NB (SB to Lamington)	25.5	188.7	2.1	0.3	25%	1.8	Partial	Yes	Yes			0	

Table 8B. Summary of HUC11 Remaining Available Water and Full Allocation

					Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
35	**02030105010**	Raritan River SB (above Spruce Run)	2020	3.9	5.5	140%	0.0	10.2	258%	0.0	Potable	100%	Potable	100%
43	**02030105020**	Raritan River SB (3 Brdgs to	2016	4.5	-0.8	Net Gain	5.3	2.8	61%	1.8	Ag/Irr	3%	Potable	43%

DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Current: Net Dep-Con (mgd)	Current: % Available Used	Current: Remaining Available Water (mgd)	Full Allocation (F.A.): Net Dep-Con (mgd)	Full Allocation (F.A.): % Available Used	Full Allocation (F.A.): Remaining Available Water (mgd)	Largest Dep-Con Loss: Largest Loss Current Use	Largest Dep-Con Loss: Largest Loss % Available Water (Current)	Largest Dep-Con Loss: Largest Loss F.A. Use	Largest Dep-Con Loss: Largest Loss % Available Water (F.A.)
		Spruce Run)												
54	**02030105030**	Neshanic River	2013	0.8	0.8	107%	0.0	2.6	336%	0.0	Potable	57%	Potable	100%
52	**02030105040**	Raritan River SB (NB to Three Bridges)	2016	1.5	0.6	39%	0.9	1.7	113%	0.0	Non-Ag Irr	27%	Potable	79%
33	**02030105050**	Lamington River	2016	5.8	2.4	41%	3.4	9.1	156%	0.0	Potable	32%	Potable	100%
40	**02030105060**	Raritan River NB (above Lamington)	2016	3.6	-0.9	Net Gain	4.5	0.7	20%	2.8	Non-Ag Irr	12%	Non-Ag Irr	18%
49	**02030105070**	Raritan River NB (SB to Lamington)	2020	0.4	0.3	75%	0.1	1.3	302%	0.0	Potable	75%	Potable	100%

Table 8C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply: UnGW	Public Supply: Non-RSW SW	Domestic: UnGW	Com/Ind/Min: UnGW	Com/Ind/Min: SW	Ag/Irr: UnGW	Ag/Irr: SW	Non-Ag Irr: UnGW	Non-Ag Irr: SW	Power Gen: UnGW	Power Gen: SW	Combined: SFD Adj UnGW	Combined: SW	Combined: Leakage	Combined: Total	RSW Withdrawals
35	**02030105010**	Raritan River SB (above Spruce Run)	6.4	0.0	1.2	0.0	0.0	0.3	0.0	0.1	0.1	0.0	0.0	7.2	0.2	0.0	7.3	0.0
43	**02030105020**	Raritan River SB (3 Brdgs to Spruce Run)	2.1	0.0	1.6	0.2	0.3	0.1	0.0	0.0	0.1	0.0	0.0	3.6	0.4	0.0	4.0	9.5
54	**02030105030**	Neshanic River	0.3	0.0	1.0	0.0	0.0	0.1	0.0	0.2	0.2	0.0	0.0	1.5	0.2	0.0	1.7	0.0
52	**02030105040**	Raritan River SB (NB to Three Bridges)	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	1.0	0.4	0.0	1.5	0.0
33	**02030105050**	Lamington River	3.9	0.0	1.1	0.1	1.1	0.1	0.0	0.1	0.3	0.0	0.0	4.8	1.4	0.0	6.2	0.0
40	**02030105060**	Raritan River	0.3	0.0	1.1	0.0	0.0	0.0	0.0	0.3	0.2	0.0	0.0	1.6	0.2	0.0	1.8	0.0

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/ Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
		NB (above Lamington)																
49	**02030105070**	Raritan River NB (SB to Lamington)	0.2	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.9	0.0

Table 8D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
35	**02030105010**	Raritan River SB (above Spruce Run)	0.0	0.9	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.9	1.8
43	**02030105020**	Raritan River SB (3 Brdgs to Spruce Run)	0.0	3.2	0.0	1.2	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	1.4	3.4	4.8
54	**02030105030**	Neshanic River	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.8
52	**02030105040**	Raritan River SB (NB to Three Bridges)	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.9
33	**02030105050**	Lamington River	0.0	1.8	0.0	0.9	0.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.8	3.8
40	**02030105060**	Raritan River NB (above Lamington)	0.0	1.8	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.8	2.7
49	**02030105070**	Raritan River NB (SB to Lamington)	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.6

Notes (applicability may vary by WMA)

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.

3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.
4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.
5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

Draft for Public Comment

WATERSHED MANAGEMENT AREA 09

LOWER RARITAN, SOUTH, AND LAWRENCE

Table 9A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
51	**02030105080**	Raritan River Lower (Millstone to NB/SB)	24.7	492.6	1.3	0.1	25%	1.2		Yes	Yes	Yes	Yes	6	
47	**02030105120**	Raritan R Lower (Lawrence to Millstone)	119.3	896.3	18.6	5.0	25%	13.6	Partial	Yes	Yes	Yes	Yes	2	
60	**02030105130**	Lawrence Brook	46.2	46.2	7.4	2.1	25%	5.3			Yes		Yes	8	
63	**02030105140**	Manalapan Brook	43.9	43.9	16.2	5.9	25%	10.3					Yes	8	
65	**02030105150**	Matchaponix Brook	44.3	44.2	20.5	10.4	25%	10.1					Yes	2	
55	**02030105160**	Raritan R Lower (below Lawrence)	73.2	1,103.8	14.9	2.5	25%	12.4			Yes	Yes	Yes	8	

Table 9B. Summary of HUC11 Remaining Available Water and Full Allocation

					Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
51	**02030105080**	Raritan River Lower (Millstone to NB/SB)	2017	0.3	0.5	185%	0.0	1.1	388%	0.0	Non-Ag Irr	96%	Non-Ag Irr	100%
47	**02030105120**	Raritan R Lower (Lawrence to Millstone)	2013	3.4	10.2	301%	0.0	51.3	1,512%	0.0	Potable	100%	Potable	100%

DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Current: Net Dep-Con (mgd)	Current: % Available Used	Current: Remaining Available Water (mgd)	Full Allocation (F.A.): Net Dep-Con (mgd)	Full Allocation (F.A.): % Available Used	Full Allocation (F.A.): Remaining Available Water (mgd)	Largest Dep-Con Loss: Largest Loss Current Use	Largest Dep-Con Loss: Largest Loss % Available Water (Current)	Largest Dep-Con Loss: Largest Loss F.A. Use	Largest Dep-Con Loss: Largest Loss % Available Water (F.A.)
60	**02030105130**	Lawrence Brook	2020	1.3	5.6	418%	0.0	11.4	857%	0.0	Potable	100%	Potable	100%
63	**02030105140**	Manalapan Brook	2013	2.6	2.9	114%	0.0	4.0	154%	0.0	Con Aq Leak	83%	Potable	55%
65	**02030105150**	Matchaponix Brook	2020	2.5	5.4	215%	0.0	2.6	104%	0.0	Potable	100%	Potable	85%
55	**02030105160**	Raritan R Lower (below Lawrence)	2016	3.1	11.2	360%	0.0	11.1	359%	0.0	Potable	100%	Potable	100%

Table 9C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
51	**02030105080**	Raritan River Lower (Millstone to NB/SB)	0.0	0.0	0.5	0.2	0.0	0.0	0.2	0.3	0.1	0.0	0.0	0.9	0.3	0.0	1.1	0.0
47	**02030105120**	Raritan R Lower (Lawrence to Millstone)	15.9	0.0	1.6	1.1	0.1	0.0	0.0	0.6	0.2	0.0	0.0	17.2	0.2	0.0	17.4	126.5
60	**02030105130**	Lawrence Brook	0.0	4.2	0.1	0.0	0.0	0.0	0.1	0.2	0.1	0.0	0.0	0.3	4.4	1.0	5.7	0.0
63	**02030105140**	Manalapan Brook	0.5	0.0	0.5	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0.9	0.4	2.1	3.4	0.0
65	**02030105150**	Matchaponix Brook	4.0	0.1	0.4	0.0	0.0	0.0	0.1	0.0	0.4	0.0	0.0	4.0	0.6	1.2	5.8	2.4
55	**02030105160**	Raritan R Lower (below Lawrence)	14.3	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.1	0.0	0.5	13.6	1.0

Table 9D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
51	**02030105080**	Raritan River Lower (Millstone to NB/SB)	0.0	0.0	0.0	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.6
47	**02030105120**	Raritan R Lower (Lawrence to Millstone)	0.0	5.0	0.0	1.2	1.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	2.2	5.0	7.2
60	**02030105130**	Lawrence Brook	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2
63	**02030105140**	Manalapan Brook	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.5
65	**02030105150**	Matchaponix Brook	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.4
55	**02030105160**	Raritan R Lower (below Lawrence)	0.0	0.0	0.0	0.1	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	2.4

Notes (applicability may vary by WMA)

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.
3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.
4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.
5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

WATERSHED MANAGEMENT AREA 10

MILLSTONE

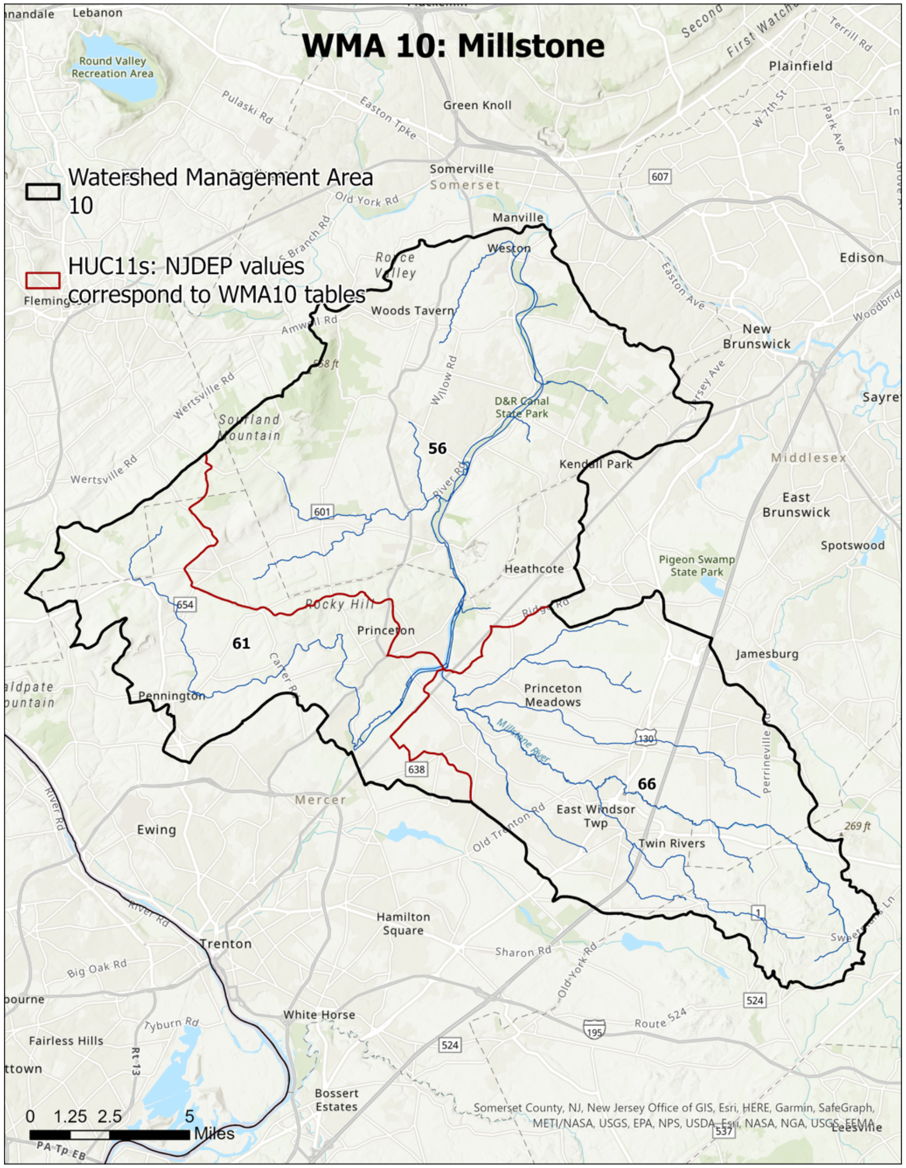

Table 10A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
61	**02030105090**	Stony Brook	55.4	55.3	3.4	0.2	25%	3.2		Yes	Yes			8	
66	**02030105100**	Millstone River (above Carnegie Lake)	98.8	98.8	18.6	4.4	25%	14.3		Yes	Yes			7	
56	**02030105110**	Millstone River (below/incl Carnegie Lk)	130.4	284.4	17.0	4.0	25%	13.0		Yes	Yes	Yes		0	

Table 10B. Summary of HUC11 Remaining Available Water and Full Allocation

DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
					Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
61	**02030105090**	Stony Brook	2016	0.8	1.2	148%	0.0	3.8	474%	0.0	Potable	100%	Potable	100%
66	**02030105100**	Millstone River (above Carnegie Lake)	2020	3.6	5.4	152%	0.0	10.0	279%	0.0	Con Aq Leak	90%	Ag/Irr	100%
56	**02030105110**	Millstone River (below/incl Carnegie Lk)	2016	3.2	-6.9	Net Gain	10.1	-5.4	Net Gain	8.7	Non-Ag Irr	23%	Potable	99%

Table 10C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/ Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
61	**02030105090**	Stony Brook	1.1	0.0	0.5	0.1	0.0	0.0	0.0	0.1	0.2	0.0	0.0	1.8	0.2	0.0	1.9	0.0

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/ Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
66	**02030105100**	Millstone River (above Carnegie Lake)	5.4	0.0	1.1	0.1	0.0	1.0	0.1	0.1	0.5	0.0	0.0	7.0	0.7	3.2	10.8	0.0
56	**02030105110**	Millstone River (below/incl Carnegie Lk)	0.2	0.0	1.3	0.2	0.0	0.2	0.0	0.3	0.5	0.0	0.0	1.9	0.5	0.0	2.5	0.0

Table 10D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
61	**02030105090**	Stony Brook	0.0	0.2	0.0	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.2	0.7
66	**02030105100**	Millstone River (above Carnegie Lake)	0.0	4.1	0.0	0.8	0.2	0.0	0.1	0.0	0.1	0.0	0.0	0.0	1.3	4.1	5.4
56	**02030105110**	Millstone River (below/incl Carnegie Lk)	0.0	8.1	0.0	0.9	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	1.2	8.2	9.4

Notes (applicability may vary by WMA)

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.
3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.
4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.
5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

WATERSHED MANAGEMENT AREA 11

CENTRAL DELAWARE

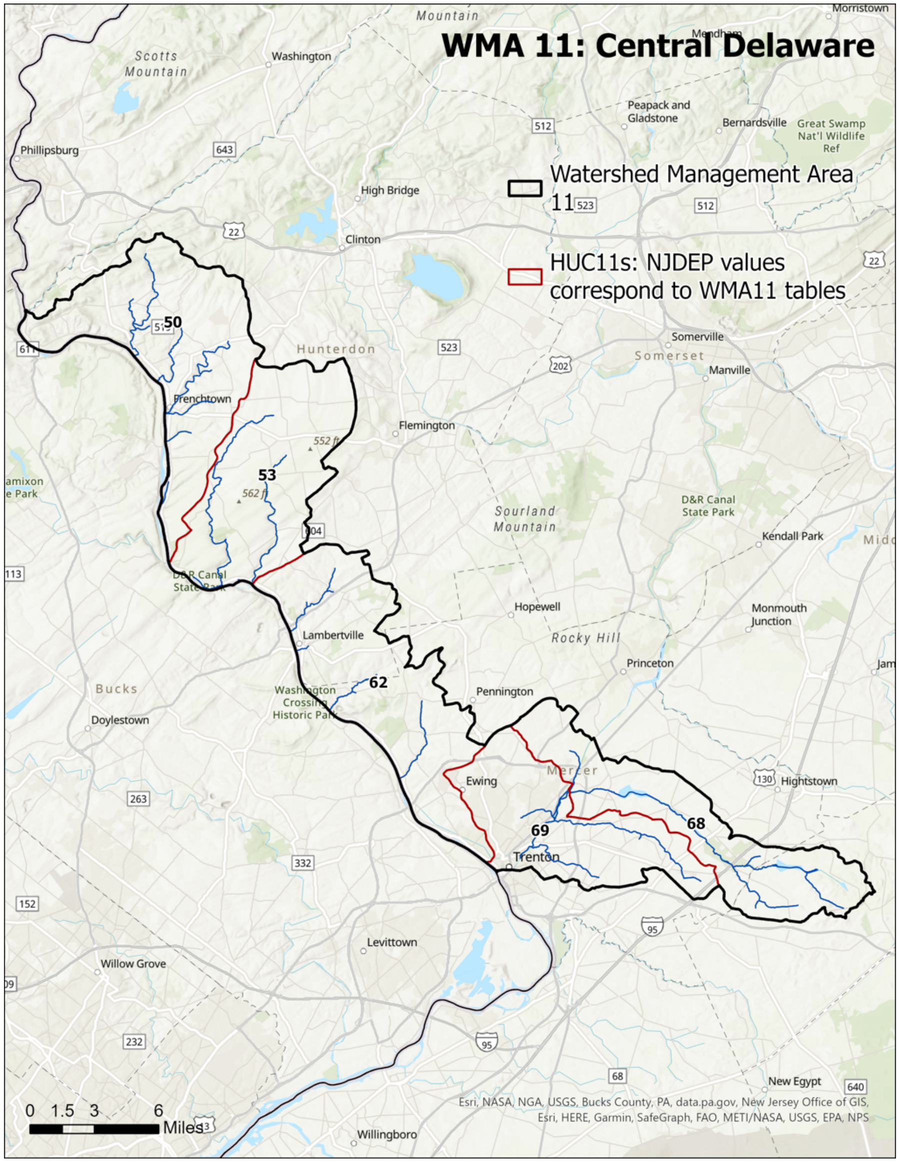

Table 11A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
50	**02040105170**	Hakihokake/ Harihokake/ Nishisakawick Ck	62.6	61.3	12.0	3.1	25%	8.9	Partial		Yes			0	
53	**02040105200**	Lockatong Creek / Wickecheoke Creek	54.4	54.1	3.1	0.4	25%	2.8			Yes			0	
62	**02040105210**	Alexauken Ck / Moore Ck / Jacobs Ck	62.6	61.1	3.2	0.2	25%	3.0			Yes			0	
68	**02040105230**	Assunpink Creek (above Shipetaukin Ck)	47.8	47.7	13.2	3.1	25%	10.1			Yes			0	
69	**02040105240**	Assunpink Creek (below Shipetaukin Ck)	44.6	92.2	13.8	5.0	25%	8.8						0	

Table 11B. Summary of HUC11 Remaining Available Water and Full Allocation

					Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
50	**02040105170**	Hakihokake/ Harihokake/ Nishisakawick Ck	2020	2.2	0.4	20%	1.8	1.8	79%	0.5	Non-Ag Irr	11%	Potable	49%
53	**02040105200**	Lockatong Creek / Wickecheoke Creek	2017	0.7	0.5	76%	0.2	2.2	315%	0.0	Ag/Irr	43%	Ag/Irr	100%

DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
					Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
62	**02040105210**	Alexauken Ck / Moore Ck / Jacobs Ck	2014	0.7	-0.1	Net Gain	0.9	1.4	185%	0.0	Non-Ag Irr	7%	Potable	100%
68	**02040105230**	Assunpink Creek (above Shipetaukin Ck)	2019	2.5	1.3	51%	1.2	4.1	162%	0.0	Con Aq Leak	23%	Potable	90%
69	**02040105240**	Assunpink Creek (below Shipetaukin Ck)	2016	2.2	-3.1	Net Gain	5.3	-1.0	Net Gain	3.2	Con Aq Leak	22%	Potable	26%

Table 11C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/ Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
50	**02040105170**	Hakihokake/ Harihokake/ Nishisakawick Ck	0.2	0.0	1.0	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.0	1.2	0.4	0.0	1.6	0.1
53	**02040105200**	Lockatong Creek / Wickecheoke Creek	0.2	0.0	0.7	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	1.1	90.3
62	**02040105210**	Alexauken Ck / Moore Ck / Jacobs Ck	0.2	0.3	1.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	1.2	0.3	0.0	1.5	27.4
68	**02040105230**	Assunpink Creek (above Shipetaukin Ck)	0.4	0.0	0.5	0.0	0.0	0.0	0.2	0.0	0.3	0.0	0.0	0.8	0.5	0.6	1.9	0.0
69	**02040105240**	Assunpink Creek (below Shipetaukin Ck)	3.6	0.0	0.3	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	3.7	0.0	0.5	4.2	0.0

Table 11D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
50	**02040105170**	Hakihokake/ Harihokake/ Nishisakawick Ck	0.0	0.3	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.4	1.1
53	**02040105200**	Lockatong Creek / Wickecheoke Creek	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.6
62	**02040105210**	Alexauken Ck / Moore Ck / Jacobs Ck	0.0	0.8	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	1.6
68	**02040105230**	Assunpink Creek (above Shipetaukin Ck)	0.0	0.1	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.6
69	**02040105240**	Assunpink Creek (below Shipetaukin Ck)	0.0	7.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	7.1	7.3

<u>**Notes (applicability may vary by WMA)**</u>

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.
3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.
4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.
5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

WATERSHED MANAGEMENT AREA 12

MONMOUTH

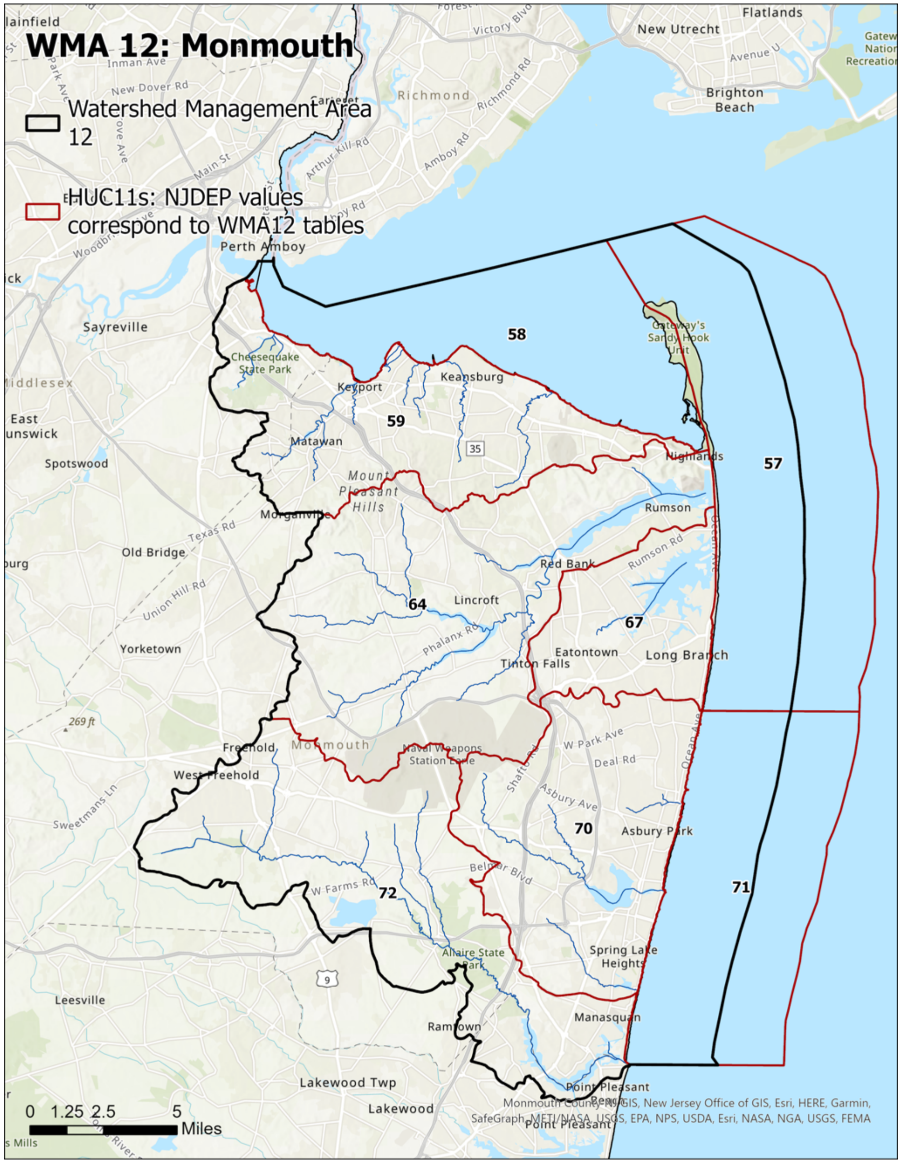

Table 12A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi²)	Watershed Area (mi²)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
59	**02030104060**	Raritan / Sandy Hook Bay tributaries	58.6	58.5	27.7	10.7	25%	17.0						0	Yes
64	**02030104070**	Navesink River / Lower Shrewsbury River	94.7	94.6	42.8	18.4	25%	24.5		Yes				0	
67	**02030104080**	Shrewsbury River (above Navesink River)	29.2	29.4	15.6	7.0	25%	8.7		Yes				0	
70	**02030104090**	Whale Pond Bk / Shark R / Wreck Pond Bk	60.7	60.7	29.6	16.1	25%	13.5		Yes				0	
72	**02030104100**	Manasquan River	82.4	82.5	38.4	18.2	25%	20.2		Yes				0	
58	**02030104910**	Raritan Bay / Sandy Hook Bay	50.5	50.5	Not Calc.	Not Calc.	25%								Yes
57	**02030104920**	Atlantic Coast (Sandy Hook to Whale Pond)	93.4	93.4	Not Calc.	Not Calc.	25%								Yes
71	**02030104930**	Atlantic Coast (Whale Pond to Manasquan)	64.7	64.7	Not Calc.	Not Calc.	25%								Yes

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Table 12B. Summary of HUC11 Remaining Available Water and Full Allocation

					Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
59	**02030104060**	Raritan / Sandy Hook Bay tributaries	2020	4.2	0.4	10%	3.8	1.5	36%	2.7	Con Aq Leak	9%	Potable	28%
64	**02030104070**	Navesink River / Lower Shrewsbury River	2016	6.1	1.6	26%	4.5	2.1	34%	4.0	Con Aq Leak	20%	Potable	23%
67	**02030104080**	Shrewsbury River (above Navesink River)	2016	2.2	0.5	21%	1.7	0.3	15%	1.8	Con Aq Leak	13%	Potable	57%
70	**02030104090**	Whale Pond Bk / Shark R / Wreck Pond Bk	2015	3.4	0.6	17%	2.8	0.7	21%	2.7	Non-Ag Irr	14%	Non-Ag Irr	17%
72	**02030104100**	Manasquan River	2020	5.1	2.0	40%	3.0	2.5	49%	2.6	Con Aq Leak	15%	Potable	40%
58	**02030104910**	Raritan Bay / Sandy Hook Bay												
57	**02030104920**	Atlantic Coast (Sandy Hook to Whale Pond)												
71	**02030104930**	Atlantic Coast (Whale Pond to Manasquan)												

Table 12C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/ Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
59	**02030104060**	Raritan / Sandy Hook Bay tributaries	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.4	0.5	0.0
64	**02030104070**	Navesink River / Lower Shrewsbury River	0.0	0.0	1.4	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	1.4	0.2	1.2	2.9	25.6
67	**02030104080**	Shrewsbury River (above Navesink River)	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.1	0.2	0.3	0.5	0.0
70	**02030104090**	Whale Pond Bk / Shark R / Wreck Pond Bk	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.4	0.3	0.1	0.9	1.3
72	**02030104100**	Manasquan River	0.6	0.0	1.1	0.0	0.0	0.1	0.2	0.4	0.2	0.0	0.0	2.0	0.4	0.8	3.2	23.5
58	**02030104910**	Raritan Bay / Sandy Hook Bay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57	**02030104920**	Atlantic Coast (Sandy Hook to Whale Pond)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
71	**02030104930**	Atlantic Coast (Whale Pond to Manasquan)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 12D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
59	**02030104060**	Raritan / Sandy Hook Bay tributaries	0.0	0.0	13.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
64	**02030104070**	Navesink River / Lower Shrewsbury River	0.0	0.1	0.0	1.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.2	0.1	1.3
67	**02030104080**	Shrewsbury River (above Navesink River)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
70	**02030104090**	Whale Pond Bk / Shark R /	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3

DEP Value	HUC11	HUC11 Name	Sanitary Sewer UnGW	Sanitary Sewer SW Fresh	Sanitary Sewer SW Saline	Domestic Septic	Com/Ind/Min UnGW	Com/Ind/Min SW	Ag/Irr UnGW	Ag/Irr SW	Non-Ag Irr UnGW	Non-Ag Irr SW	Power Gen UnGW	Power Gen SW	Combined UnGW	Combined SW	Combined Total
		Wreck Pond Bk															
72	**02030104100**	Manasquan River	0.0	0.0	0.0	0.8	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.1	0.1	1.1
58	**02030104910**	Raritan Bay / Sandy Hook Bay	0.0	0.0	80.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57	**02030104920**	Atlantic Coast (Sandy Hook to WhalePond)	0.0	0.0	27.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
71	**02030104930**	Atlantic Coast (Whale Pond to Manasquan)	0.0	0.0	18.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes (applicability may vary by WMA)

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.
3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.
4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.
5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

WATERSHED MANAGEMENT AREA 13

BARNEGAT BAY

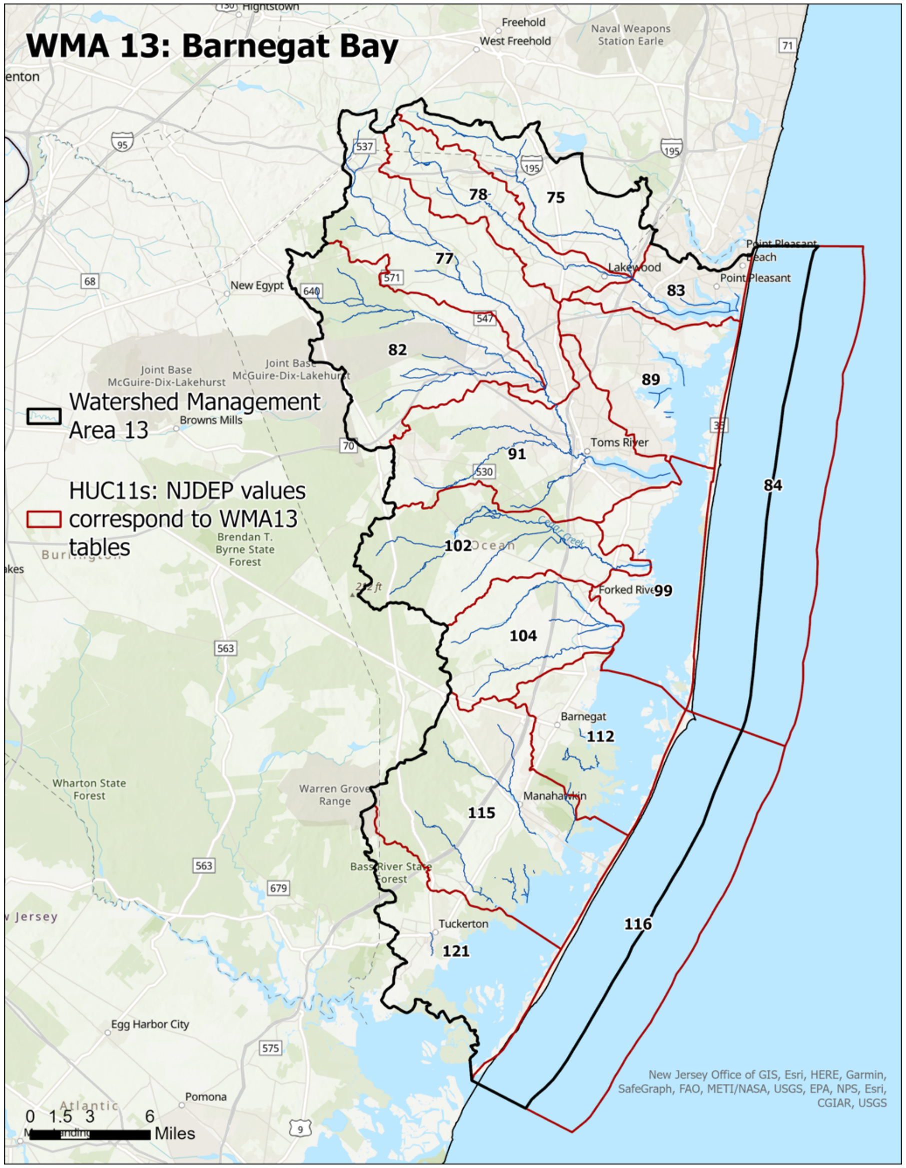

Table 13A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
75	**02040301020**	Metedeconk River NB	38.3	38.2	19.3	9.1	25%	10.2		Yes				0	
78	**02040301030**	Metedeconk River SB	30.8	30.8	18.3	9.3	25%	9.0		Yes				0	
83	**02040301040**	Metedeconk River	20.6	89.0	11.9	6.6	25%	5.3		Yes				8	
89	**02040301050**	Kettle Creek / Barnegat Bay North	46.7	31.3	27.0	15.0	25%	12.1				Yes		7	
77	**02040301060**	Toms River (above Oak Ridge Parkway)	60.3	123.3	40.4	29.9	25%	10.5						8	
82	**02040301070**	Union/Ridgeway Branch (Toms River)	63.1	63.1	33.3	13.1	25%	20.3						0	
91	**02040301080**	Toms River (below Oak Ridge Parkway)	68.4	191.3	77.4	53.6	25%	23.8				Yes		8	
102	**02040301090**	Cedar Creek	55.0	67.8	50.2	23.3	25%	26.9						0	
99	**02040301100**	Barnegat Bay Central & Tribs	45.8	468.0	Not Calc.	Not Calc.	25%	22.4				Yes		0	
104	**02040301110**	Forked River / Oyster Creek	38.9	38.9	40.8	25.1	25%	15.7						0	
112	**02040301120**	Waretown Ck / Barnegat Bay South	47.0	24.9	62.1	39.7	25%	22.4						0	
115	**02040301130**	Manahawkin/ Upper Little Egg Harbor tribs	87.9	71.6	71.9	46.3	25%	25.6						0	
121	**02040301140**	Lower Little Egg Harbor Bay tribs	53.8	35.2	18.0	7.4	25%	10.7						0	

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi²)	Watershed Area (mi²)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
84	**02040301910**	Atlantic Coast (Manasquan to Barnegat)	139.0	139.0	Not Calc.	Not Calc.	25%								Yes
116	**02040301920**	Atlantic Coast (Barnegat to Little Egg)	121.6	121.6	Not Calc.	Not Calc.	25%								Yes

Table 13B. Summary of HUC11 Remaining Available Water and Full Allocation

					Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
75	**02040301020**	Metedeconk River NB	2020	2.5	0.5	19%	2.1	1.3	50%	1.3	Con Aq Leak	11%	Potable	38%
78	**02040301030**	Metedeconk River SB	2020	2.2	1.2	54%	1.0	1.7	77%	0.5	Potable	27%	Potable	35%
83	**02040301040**	Metedeconk River	2013	1.3	3.0	224%	0.0	4.4	329%	0.0	Potable	100%	Non-Ag Irr	100%
89	**02040301050**	Kettle Creek / Barnegat Bay North	2016	3.0	3.9	129%	0.0	4.6	154%	0.0	Potable	89%	Potable	81%
77	**02040301060**	Toms River (above Oak Ridge Parkway)	2016	2.6	4.5	172%	0.0	7.6	290%	0.0	Non-Ag Irr	62%	Potable	100%
82	**02040301070**	Union/Ridgeway Branch (Toms River)	2016	5.1	1.9	38%	3.1	2.4	47%	2.7	Potable	17%	Potable	36%
91	**02040301080**	Toms River (below Oak Ridge Parkway)	2014	5.9	8.3	140%	0.0	8.9	150%	0.0	Potable	100%	Potable	100%
102	**02040301090**	Cedar Creek	2013	6.7	2.1	31%	4.7	3.6	54%	3.1	Con Aq Leak	13%	Potable	38%
99	**02040301100**	Barnegat Bay Central & Tribs												

DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
					Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
104	**02040301110**	Forked River / Oyster Creek	2013	3.9	0.7	19%	3.2	1.5	39%	2.4	Con Aq Leak	16%	Potable	23%
112	**02040301120**	Waretown Ck / Barnegat Bay South	2015	5.6	1.2	21%	4.4	1.7	31%	3.9	Potable	10%	Potable	19%
115	**02040301130**	Manahawkin/ Upper Little Egg Harbor tribs	2016	6.4	2.0	31%	4.4	4.5	71%	1.9	Con Aq Leak	17%	Potable	30%
121	**02040301140**	Lower Little Egg Harbor Bay tribs	2017	2.7	0.7	28%	1.9	1.4	52%	1.3	Non-Ag Irr	15%	Potable	41%
84	**02040301910**	Atlantic Coast (Manasquan to Barnegat)												
116	**02040301920**	Atlantic Coast (Barnegat to Little Egg)												

Table 13C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/ Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
75	**02040301020**	Metedeconk River NB	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.0	0.0	0.3	1.3	0.0
78	**02040301030**	Metedeconk River SB	0.6	0.0	0.7	0.0	0.0	0.0	0.1	0.1	0.2	0.0	0.0	1.2	0.2	0.3	1.8	0.0
83	**02040301040**	Metedeconk River	2.1	0.0	0.1	0.1	0.0	0.0	0.0	1.3	0.0	0.0	0.0	3.2	0.0	0.0	3.2	0.0
89	**02040301050**	Kettle Creek / Barnegat Bay North	2.9	0.0	0.4	0.6	0.0	0.2	0.0	1.3	0.0	0.0	0.0	4.9	0.0	0.0	4.9	0.0
77	**02040301060**	Toms River (above Oak	1.0	0.0	2.7	0.5	2.3	0.1	0.0	0.9	1.0	0.0	0.0	4.7	3.3	1.4	9.4	0.0

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/ Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
		Ridge Parkway)																
82	02040301070	Union/Ridgeway Branch (Toms River)	0.9	0.0	0.3	0.2	0.0	0.0	0.0	0.7	0.0	0.0	0.0	1.9	0.0	0.5	2.4	0.0
91	02040301080	Toms River (below Oak Ridge Parkway)	8.7	0.0	0.7	1.6	0.0	0.0	0.0	0.4	0.0	0.0	0.0	10.3	0.0	0.0	10.3	0.0
102	02040301090	Cedar Creek	0.7	0.0	0.4	0.0	4.8	0.0	0.0	0.0	0.0	0.0	0.0	1.0	4.8	0.8	6.7	0.0
99	02040301100	Barnegat Bay Central & Tribs	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.2	1.0	0.0
104	02040301110	Forked River / Oyster Creek	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.6	1.3	0.0
112	02040301120	Waretown Ck / Barnegat Bay South	0.6	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.8	0.2	0.4	1.4	0.0
115	02040301130	Manahawkin/Upper Little Egg Harbor tribs	0.2	0.0	1.3	0.0	3.3	0.0	0.0	0.1	0.1	0.0	0.0	1.4	3.4	1.1	5.9	0.0
121	02040301140	Lower Little Egg Harbor Bay tribs	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.3	0.2	0.0	0.0	0.6	0.2	0.3	1.1	0.0
84	02040301910	Atlantic Coast (Manasquan to Barnegat)	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0
116	02040301920	Atlantic Coast (Barnegat to Little Egg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 13D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
75	02040301020	Metedeconk River NB	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.8
78	02040301030	Metedeconk River SB	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.6
83	02040301040	Metedeconk River	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.2

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DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
89	**02040301050**	Kettle Creek / Barnegat Bay North	0.0	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.0	0.0	1.0
77	**02040301060**	Toms River (above Oak Ridge Parkway)	0.0	0.0	0.0	2.0	0.5	2.2	0.0	0.0	0.1	0.1	0.0	0.0	2.6	2.3	4.9
82	**02040301070**	Union/Ridgeway Branch (Toms River)	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.5	0.0	0.5
91	**02040301080**	Toms River (below Oak Ridge Parkway)	0.0	0.0	0.0	0.5	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0
102	**02040301090**	Cedar Creek	0.0	0.0	0.0	0.3	0.0	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.3	4.4	4.7
99	**02040301100**	Barnegat Bay Central & Tribs	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.7
104	**02040301110**	Forked River / Oyster Creek	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.6
112	**02040301120**	Waretown Ck / Barnegat Bay South	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3
115	**02040301130**	Manahawkin/Upper Little Egg Harbor tribs	0.0	0.0	0.0	0.9	0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.0	3.9
121	**02040301140**	Lower Little Egg Harbor Bay tribs	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3
84	**02040301910**	Atlantic Coast (Manasquan to Barnegat)	0.0	0.0	40.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
116	**02040301920**	Atlantic Coast (Barnegat to Little Egg)	0.0	0.0	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes (applicability may vary by WMA)

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.
3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.

4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.
5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

WATERSHED MANAGEMENT AREA 14

MULLICA

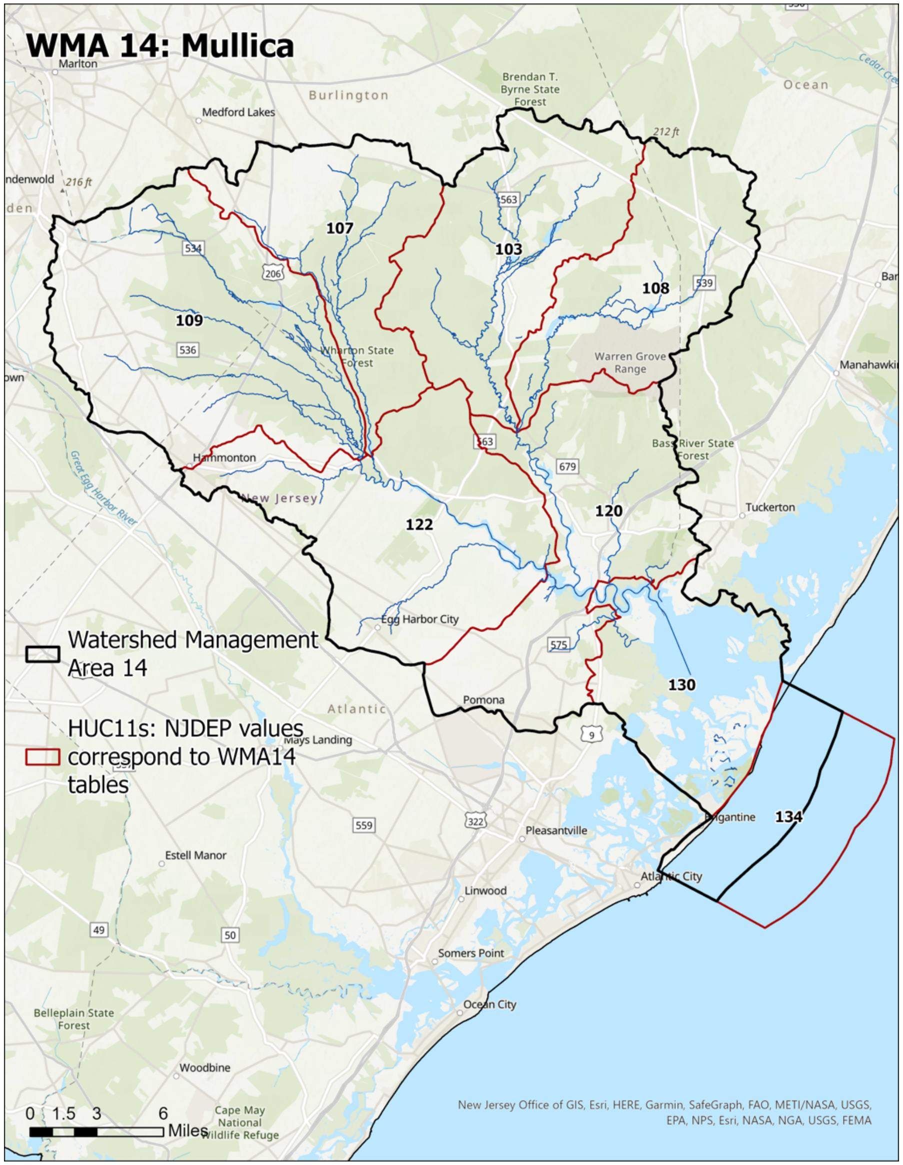

Table 14A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
107	**02040301150**	Basto River	67.9	67.9	43.7	26.0	25%	17.7						0	
109	**02040301160**	Mullica River (above Basto River)	127.3	127.3	48.4	19.4	25%	28.9						2	
122	**02040301170**	Mullica River (Turtle Ck to Basto River)	110.0	305.0	53.7	22.9	25%	30.8				Yes		0	
108	**02040301180**	Oswego River	72.6	72.5	30.4	13.8	25%	16.7						0	
103	**02040301190**	West Branch Wading River	87.1	87.0	38.6	17.2	25%	21.4						0	
120	**02040301200**	Mullica River (GSP bridge to Turtle Ck)	95.7	560.2	56.4	29.6	25%	26.8				Yes		0	
130	**02040301210**	Great Bay / Mullica R (below GSP bridge)	64.6	581.9	19.5	3.9	25%	15.6			Yes	Yes		0	
134	**02040302910**	Atlantic Coast (Little Egg to Absecon)	59.1	59.1	Not Calc.	Not Calc.	25%								

Table 14B. Summary of HUC11 Remaining Available Water and Full Allocation

					Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
107	**02040301150**	Basto River	2013	4.4	2.5	57%	1.9	7.7	173%	0.0	Ag/Irr	49%	Ag/Irr	100%
109	**02040301160**	Mullica River	2013	7.2	7.7	106%	0.0	28.3	391%	0.0	Ag/Irr	70%	Ag/Irr	100%

DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
					Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
		(above Basto River)												
122	**02040301170**	Mullica River (Turtle Ck to Basto River)	2018	7.7	6.3	82%	1.4	19.9	258%	0.0	Ag/Irr	50%	Ag/Irr	100%
108	**02040301180**	Oswego River	2017	4.2	1.0	24%	3.2	8.0	192%	0.0	Ag/Irr	9%	Potable	100%
103	**02040301190**	West Branch Wading River	2013	5.3	0.6	11%	4.8	2.1	40%	3.2	Con Aq Leak	8%	Ag/Irr	29%
120	**02040301200**	Mullica River (GSP bridge to Turtle Ck)	2019	6.7	3.5	52%	3.2	5.8	86%	1.0	Potable	29%	Ag/Irr	37%
130	**02040301210**	Great Bay / Mullica R (below GSP bridge)	2017	3.9	0.6	15%	3.3	0.2	5%	3.7	Potable	15%	Potable	23%
134	**02040302910**	Atlantic Coast (Little Egg to Absecon)												

Table 14C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/ Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
107	**02040301150**	Basto River	0.0	0.0	1.2	0.0	0.0	2.3	0.7	0.0	0.0	0.0	0.0	3.2	0.7	0.2	4.1	0.0
109	**02040301160**	Mullica River (above Basto River)	1.4	0.0	2.2	0.1	0.0	6.0	0.3	0.1	0.0	0.0	0.0	8.8	0.4	0.9	10.0	0.0
122	**02040301170**	Mullica River (Turtle Ck to	0.6	0.0	1.2	0.0	0.0	4.8	0.0	0.1	0.0	0.0	0.0	6.1	0.0	1.6	7.7	0.0

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/ Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
		Basto River)																
108	**02040301180**	Oswego River	0.0	0.0	0.1	0.0	7.2	0.5	4.1	0.0	0.0	0.0	0.0	0.5	11.4	0.2	12.1	0.0
103	**02040301190**	West Branch Wading River	0.0	0.0	0.1	0.0	0.0	2.4	2.5	0.0	0.0	0.0	0.0	2.3	2.5	0.4	5.2	0.0
120	**02040301200**	Mullica River (GSP bridge to Turtle Ck)	2.1	0.0	0.4	0.3	0.0	0.7	0.1	0.1	0.0	0.0	0.0	3.2	0.1	0.9	4.2	0.0
130	**02040301210**	Great Bay / Mullica R (below GSP bridge)	0.6	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.7	0.0
134	**02040302910**	Atlantic Coast (Little Egg to Absecon)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 14D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
107	**02040301150**	Basto River	0.0	0.0	0.0	0.9	0.0	0.0	0.4	0.2	0.0	0.0	0.0	0.0	1.3	0.2	1.6
109	**02040301160**	Mullica River (above Basto River)	0.0	0.0	0.0	1.6	0.1	0.0	0.6	0.1	0.0	0.0	0.0	0.0	2.3	0.1	2.4
122	**02040301170**	Mullica River (Turtle Ck to Basto River)	0.0	0.0	0.0	0.9	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	1.4	0.0	1.4
108	**02040301180**	Oswego River	0.0	0.0	0.0	0.0	0.0	6.9	0.1	4.1	0.0	0.0	0.0	0.0	0.1	11.0	11.1
103	**02040301190**	West Branch Wading River	0.0	0.0	0.0	0.1	0.0	0.0	2.1	2.5	0.0	0.0	0.0	0.0	2.2	2.5	4.6
120	**02040301200**	Mullica River (GSP bridge to Turtle Ck)	0.0	0.0	0.0	0.3	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.7
130	**02040301210**	Great Bay / Mullica R (below GSP bridge)	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1

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DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
134	**02040302910**	Atlantic Coast (Little Egg to Absecon)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes (applicability may vary by WMA)

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.
3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.
4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.
5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

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WATERSHED MANAGEMENT AREA 15

GREAT EGG HARBOR

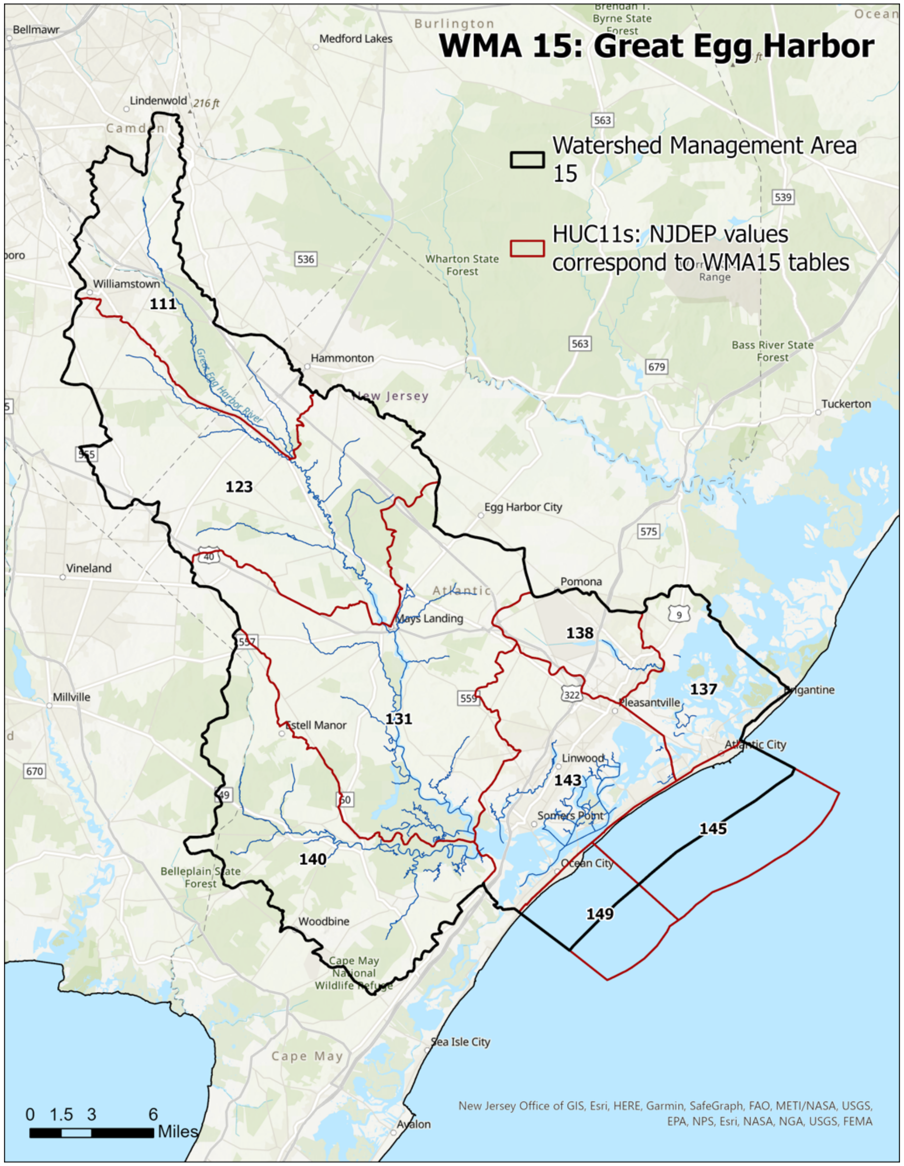

Table 15A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
137	**02040302010**	Reeds Bay / Absecon Bay & tribs	39.3	14.8	12.7	3.4	25%	9.4			Yes	Yes	Yes	0	
138	**02040302020**	Absecon Creek	26.4	26.4	11.5	5.8	25%	5.7					Yes	8	
111	**02040302030**	Great Egg Harbor R (above HospitalityBr)	71.1	71.0	35.5	17.5	25%	18.0					Yes	5	
123	**02040302040**	Great Egg Harbor R (Lk Lenape to HospBr)	133.5	204.4	59.2	13.7	25%	45.5			Yes	Yes	Yes	0	
131	**02040302050**	Great Egg Harbor R (below Lake Lenape)	142.2	346.5	52.6	21.1	25%	31.5				Yes	Yes	0	
143	**02040302060**	Patcong Creek/ Great Egg Harbor Bay	71.0	42.7	30.0	15.8	25%	14.2				Yes	Yes	8	
140	**02040302070**	Tuckahoe River	102.4	102.1	36.6	15.5	25%	21.1					Yes	0	
145	**02040302920**	Atlantic Coast (Absecon to Great Egg)	54.0	54.0	Not Calc.	Not Calc.	25%								Yes
149	**02040302930**	Atlantic Coast (Great Egg to 34th St)	26.9	27.0	Not Calc.	Not Calc.	25%								

Table 15B. Summary of HUC11 Remaining Available Water and Full Allocation

DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
					Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
137	**02040302010**	Reeds Bay / Absecon Bay & tribs	2013	2.3	0.6	24%	1.8	1.0	43%	1.3	Non-Ag Irr	20%	Non-Ag Irr	32%
138	**02040302020**	Absecon Creek	2013	1.4	14.2	1,000%	0.0	29.2	2,054%	0.0	Potable	100%	Potable	100%
111	**02040302030**	Great Egg Harbor R (above HospitalityBr)	2018	4.5	5.9	131%	0.0	19.7	438%	0.0	Potable	82%	Potable	100%
123	**02040302040**	Great Egg Harbor R (Lk Lenape to HospBr)	2016	11.4	10.0	88%	1.3	24.7	217%	0.0	Ag/Irr	66%	Ag/Irr	100%
131	**02040302050**	Great Egg Harbor R (below Lake Lenape)	2017	7.9	4.4	55%	3.5	9.9	125%	0.0	Potable	22%	Potable	65%
143	**02040302060**	Patcong Creek/ Great Egg Harbor Bay	2013	3.6	7.2	202%	0.0	11.0	310%	0.0	Potable	100%	Potable	100%
140	**02040302070**	Tuckahoe River	2018	5.3	3.1	58%	2.2	5.5	105%	0.0	Con Aq Leak	30%	Com/Ind/ Min	26%
145	**02040302920**	Atlantic Coast (Absecon to Great Egg)												
149	**02040302930**	Atlantic Coast (Great Egg to 34th St)												

Table 15C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/ Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
137	**02040302010**	Reeds Bay / Absecon Bay & tribs	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.7	0.0	0.0	0.8	0.0
138	**02040302020**	Absecon Creek	10.7	4.3	0.8	1.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	11.4	4.3	0.1	15.7	0.0
111	**02040302030**	Great Egg Harbor R (above HospitalityBr)	3.9	0.0	1.4	0.0	1.6	2.5	0.1	0.0	0.0	0.0	0.0	7.0	1.7	0.0	8.7	0.0
123	**02040302040**	Great Egg Harbor R (Lk Lenape to HospBr)	0.9	0.0	1.6	0.0	3.4	9.3	0.0	0.2	0.0	0.0	0.0	10.9	3.4	1.4	15.7	0.0
131	**02040302050**	Great Egg Harbor R (below Lake Lenape)	1.6	0.0	1.9	0.3	0.0	0.9	0.0	0.6	0.5	0.0	0.0	4.7	0.6	0.9	6.2	0.0
143	**02040302060**	Patcong Creek/Great Egg Harbor Bay	7.4	0.0	1.0	0.1	0.0	0.1	0.1	0.5	0.1	0.1	0.0	8.2	0.1	0.1	8.5	0.0
140	**02040302070**	Tuckahoe River	0.4	0.0	0.5	0.1	7.0	0.9	0.0	0.0	0.0	0.0	0.0	1.7	7.0	1.6	10.2	0.0
145	**02040302920**	Atlantic Coast (Absecon to Great Egg)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
149	**02040302930**	Atlantic Coast (Great Egg to 34th St)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 15D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
137	**02040302010**	Reeds Bay / Absecon Bay & tribs	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.2
138	**02040302020**	Absecon Creek	0.0	0.0	0.0	0.6	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	1.5
111	**02040302030**	Great Egg Harbor R (above HospitalityBr)	0.0	0.0	0.0	1.0	0.0	1.5	0.3	0.0	0.0	0.0	0.0	0.0	1.3	1.5	2.8
123	**02040302040**	Great Egg	0.0	0.3	0.0	1.2	0.0	3.2	0.9	0.0	0.0	0.0	0.0	0.0	2.2	3.5	5.7

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
		Harbor R (Lk Lenape to HospBr)															
131	**02040302050**	Great Egg Harbor R (below Lake Lenape)	0.0	0.0	0.0	1.4	0.2	0.0	0.1	0.0	0.1	0.1	0.0	0.0	1.8	0.1	1.9
143	**02040302060**	Patcong Creek/ Great Egg Harbor Bay	0.0	0.0	0.0	0.7	0.5	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.3	0.0	1.3
140	**02040302070**	Tuckahoe River	0.0	0.0	0.0	0.4	0.1	6.6	0.1	0.0	0.0	0.0	0.0	0.0	0.6	6.6	7.2
145	**02040302920**	Atlantic Coast (Absecon to Great Egg)	0.0	0.0	27.5	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4
149	**02040302930**	Atlantic Coast (Great Egg to 34th St)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes (applicability may vary by WMA)

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.
3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.
4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.
5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

WATERSHED MANAGEMENT AREA 16

CAPE MAY

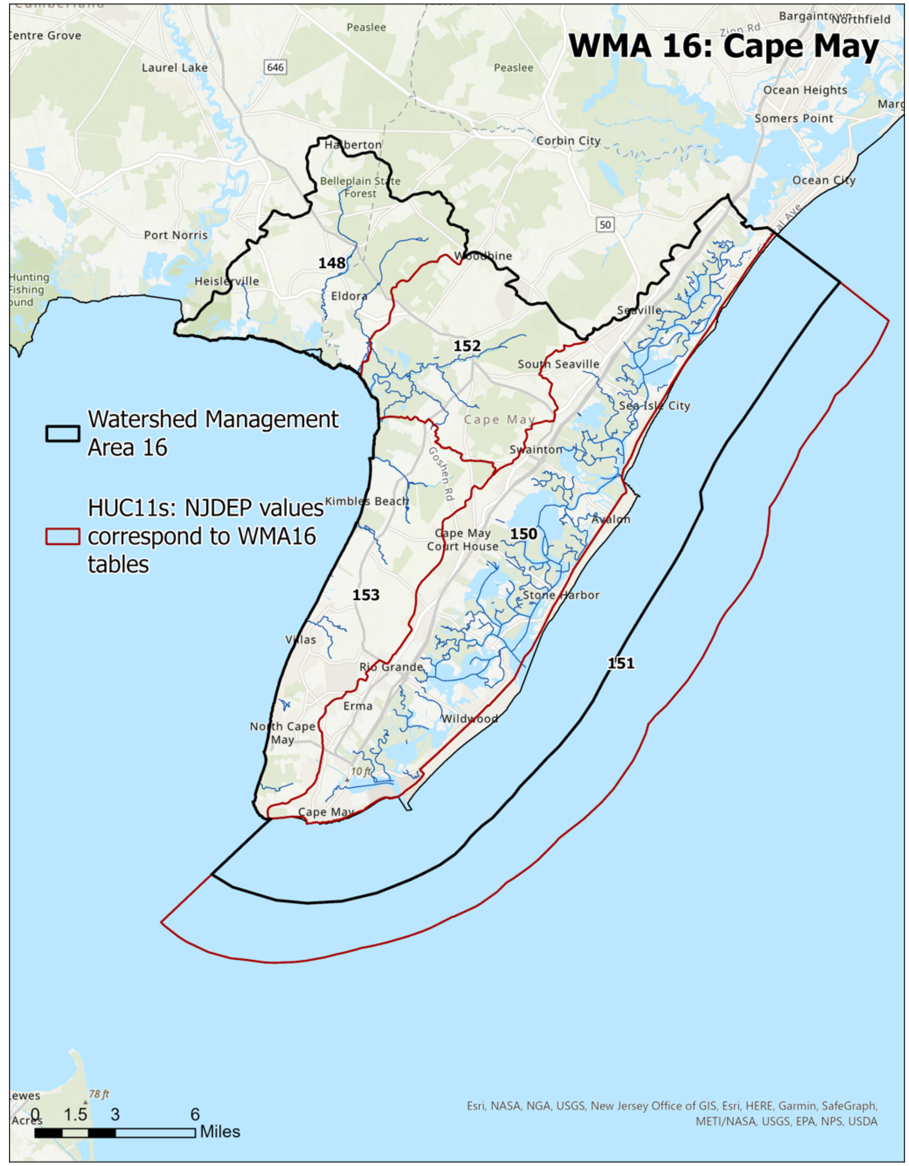

Table 16A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi²)	Watershed Area (mi²)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
148	**02040206210**	West Creek / East Creek / Riggins Ditch	45.3	45.3	6.7	1.2	25%	5.5			Yes			0	
152	**02040206220**	Dennis Creek	41.2	41.2	5.3	0.7	25%	4.5			Yes			0	
153	**02040206230**	Cape May Tribs West	45.2	45.1	5.5	1.5	25%	3.9			Yes			0	Yes
150	**02040302080**	Cape May Bays & Tribs East	103.2	69.1	17.6	4.6	25%	13.0			Yes			0	Yes
151	**02040302940**	Atlantic Coast (34th St to Cape May Pt)	191.0	191.0	Not Calc.	Not Calc.	25%								

Table 16B. Summary of HUC11 Remaining Available Water and Full Allocation

DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
					Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
148	**02040206210**	West Creek / East Creek / Riggins Ditch	2013	1.4	1.0	69%	0.4	2.7	193%	0.0	Ag/Irr	73%	Ag/Irr	100%
152	**02040206220**	Dennis Creek	2016	1.1	0.4	37%	0.7	3.7	329%	0.0	Ag/Irr	27%	Ag/Irr	100%
153	**02040206230**	Cape May Tribs West	2016	1.0	0.9	91%	0.1	6.2	632%	0.0	Potable	82%	Potable	100%
150	**02040302080**	Cape May Bays & Tribs East	2016	3.2	-0.6	Net Gain	3.8	2.4	75%	0.8	Non-Ag Irr	31%	Potable	48%
151	**02040302940**	Atlantic Coast												

DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
					Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
		(34th St to Cape May Pt)												

Table 16C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/ Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
148	**02040206210**	West Creek / East Creek / Riggins Ditch	0.0	0.0	0.2	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.5	1.8	0.0
152	**02040206220**	Dennis Creek	0.0	0.0	0.3	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.1	0.6	0.0
153	**02040206230**	Cape May Tribs West	1.9	0.6	1.8	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.7	0.0	4.2	0.0
150	**02040302080**	Cape May Bays & Tribs East	1.3	0.1	2.4	0.3	0.4	0.2	0.0	0.9	0.3	0.0	0.0	4.6	0.8	0.1	5.5	0.0
151	**02040302940**	Atlantic Coast (34th St to Cape May Pt)	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.6	0.0

Table 16D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
148	**02040206210**	West Creek / East Creek / Riggins Ditch	0.0	0.6	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.9
152	**02040206220**	Dennis Creek	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2
153	**02040206230**	Cape May	0.0	1.8	1.3	1.4	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.4	1.9	3.3

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
		Tribs West															
150	**02040302080**	Cape May Bays & Tribs East	0.0	3.4	14.2	1.8	0.3	0.3	0.1	0.0	0.1	0.0	0.0	0.0	2.3	3.8	6.1
151	**02040302940**	Atlantic Coast (34th St to Cape May Pt)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes (applicability may vary by WMA)

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.
3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.
4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.
5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

WATERSHED MANAGEMENT AREA 17

MAURICE, SALEM, AND COHANSEY

Table 17A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
141	**02040204910**	Delaware Bay (Cape May Pt to Fishing Ck)	348.6	348.6	Not Calc.	Not Calc.	25%								
114	**02040206020**	Pennsville / Penns Grove tribs	13.7	22.7	3.0	1.3	25%	1.7					Yes	0	Yes
117	**02040206030**	Salem R (above 39d40m14s dam)/ Salem Canal	58.3	58.3	12.9	5.4	25%	7.5					Yes	7	
124	**02040206040**	Salem River (below 39d40m14s dam)	58.9	58.6	13.0	3.1	25%	9.8			Yes		Yes	3	Yes
127	**02040206060**	Alloway Creek / Hope Creek	85.8	77.5	22.8	4.1	25%	18.7			Yes		Yes	0	Yes
133	**02040206070**	Stow Creek	55.2	55.0	24.6	8.9	25%	15.7					Yes	0	Yes
129	**02040206080**	Cohansey River (above Sunset Lake)	37.4	37.4	15.9	8.8	25%	7.1					Yes	8	
139	**02040206090**	Cohansey River (below Cornwell Run)	69.7	107.0	33.3	17.2	25%	16.1				Yes	Yes	8	
144	**02040206100**	Back / Cedar / Nantuxent Creeks	51.0	51.0	10.7	3.9	25%	6.8					Yes	8	
147	**02040206110**	Dividing Creek	60.1	60.6	7.6	1.3	25%	6.3			Yes		Yes	7	
119	**02040206120**	Still Run / Little Ease Run	46.1	46.1	14.9	5.7	25%	9.2					Yes	4	
118	**02040206130**	Scotland Run	29.8	29.8	12.9	5.5	25%	7.3					Yes	8	
128	**02040206140**	Maurice River (above Sherman Ave Bridge)	56.8	190.5	42.6	15.5	25%	27.1				Yes	Yes	7	

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
126	**02040206150**	Muddy Run	57.9	57.8	20.8	10.1	25%	10.7					Yes	8	
135	**02040206160**	Maurice River (Union Lk to Sherman Ave)	25.0	215.5	10.8	5.8	25%	5.0				Yes	Yes	8	
142	**02040206170**	Maurice River (Menantico Ck to Union Lk)	44.6	260.1	11.4	4.7	25%	6.7				Yes	Yes	8	Yes
132	**02040206180**	Menantico Creek	39.2	39.2	22.9	7.8	25%	15.1					Yes	8	
136	**02040206190**	Manamuskin River	36.2	36.2	14.1	6.8	25%	7.4					Yes	0	
146	**02040206200**	Maurice River (below Menantico Creek)	48.9	384.4	20.2	9.1	25%	11.2				Yes	Yes	0	

Table 17B. Summary of HUC11 Remaining Available Water and Full Allocation

					Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
141	**02040204910**	Delaware Bay (Cape May Pt to Fishing Ck)												
114	**02040206020**	Pennsville / Penns Grove tribs	2014	0.4	-0.7	Net Gain	1.2	-3.6	Net Gain	4.0	Con Aq Leak	100%	Potable	100%
117	**02040206030**	Salem R (above 39d40m14s dam)/ Salem Canal	2017	1.9	6.1	328%	0.0	13.2	707%	0.0	Ag/Irr	100%	Ag/Irr	100%

DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
					Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
124	**02040206040**	Salem River (below 39d40m14s dam)	2018	2.5	2.7	110%	0.0	5.4	218%	0.0	Ag/Irr	70%	Ag/Irr	100%
127	**02040206060**	Alloway Creek / Hope Creek	2013	4.7	0.9	20%	3.7	7.4	158%	0.0	Ag/Irr	9%	Potable	100%
133	**02040206070**	Stow Creek	2017	3.9	1.5	38%	2.5	5.7	145%	0.0	Ag/Irr	33%	Ag/Irr	100%
129	**02040206080**	Cohansey River (above Sunset Lake)	2016	1.8	10.0	562%	0.0	46.7	2,631%	0.0	Ag/Irr	100%	Ag/Irr	100%
139	**02040206090**	Cohansey River (below Cornwell Run)	2016	4.0	7.2	179%	0.0	33.0	821%	0.0	Ag/Irr	100%	Ag/Irr	100%
144	**02040206100**	Back / Cedar / Nantuxent Creeks	2016	1.7	4.4	259%	0.0	19.1	1,116%	0.0	Ag/Irr	100%	Ag/Irr	100%
147	**02040206110**	Dividing Creek	2015	1.6	2.6	166%	0.0	3.8	242%	0.0	Com/Ind/ Min	100%	Com/Ind/ Min	100%
119	**02040206120**	Still Run / Little Ease Run	2020	2.3	3.2	138%	0.0	8.9	388%	0.0	Ag/Irr	84%	Ag/Irr	100%
118	**02040206130**	Scotland Run	2013	1.8	2.5	136%	0.0	7.6	414%	0.0	Potable	100%	Potable	100%
128	**02040206140**	Maurice River (above Sherman Ave Bridge)	2016	6.8	10.5	155%	0.0	25.8	381%	0.0	Potable	100%	Potable	100%
126	**02040206150**	Muddy Run	2017	2.7	10.5	393%	0.0	27.0	1,007%	0.0	Ag/Irr	100%	Ag/Irr	100%
135	**02040206160**	Maurice River (Union Lk to Sherman Ave)	2016	1.2	3.7	299%	0.0	10.9	878%	0.0	Ag/Irr	100%	Ag/Irr	100%

DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
					Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
142	**02040206170**	Maurice River (Menantico Ck to Union Lk)	2020	1.7	4.8	285%	0.0	9.9	590%	0.0	Potable	100%	Potable	100%
132	**02040206180**	Menantico Creek	2016	3.8	8.8	233%	0.0	27.1	719%	0.0	Ag/Irr	100%	Ag/Irr	100%
136	**02040206190**	Manamuskin River	2015	1.8	1.7	95%	0.1	5.5	298%	0.0	Ag/Irr	80%	Ag/Irr	100%
146	**02040206200**	Maurice River (below Menantico Creek)	2020	2.8	1.6	57%	1.2	4.3	155%	0.0	Con Aq Leak	39%	Potable	78%

Table 17C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
141	**02040204910**	Delaware Bay (Cape May Pt to Fishing Ck)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
114	**02040206020**	Pennsville / Penns Grove tribs	0.9	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	2.2	0.0	1.0	3.2	0.0
117	**02040206030**	Salem R (above 39d40m14s dam)/ Salem Canal	0.3	0.0	0.6	0.0	8.8	0.5	4.5	0.0	0.0	0.0	0.0	1.3	13.3	0.9	15.6	0.0
124	**02040206040**	Salem River (below 39d40m14s dam)	0.0	0.0	0.4	0.0	0.0	0.2	1.8	0.0	0.0	0.0	0.0	0.5	1.8	0.9	3.2	0.0
127	**02040206060**	Alloway Creek / Hope Creek	0.0	0.3	0.9	0.0	0.0	0.4	0.1	0.0	0.0	0.0	0.0	1.2	0.3	0.1	1.7	0.0
133	**02040206070**	Stow Creek	0.0	0.0	0.2	0.0	1.0	0.6	0.9	0.0	0.0	0.0	0.0	0.7	1.9	0.0	2.6	0.0
129	**02040206080**	Cohansey River	0.6	0.0	0.8	4.8	0.0	10.1	1.3	0.0	0.0	0.0	0.0	14.6	1.3	0.0	16.0	0.0

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/ Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
		(above Sunset Lake)																
139	**02040206090**	Cohansey River (below Cornwell Run)	2.9	0.0	1.3	0.0	1.5	7.1	1.3	0.1	0.0	0.0	0.0	10.2	2.7	0.0	13.0	0.0
144	**02040206100**	Back / Cedar / Nantuxent Creeks	0.0	0.0	0.4	0.0	0.0	5.2	0.1	0.0	0.0	0.0	0.0	5.0	0.1	0.1	5.3	0.0
147	**02040206110**	Dividing Creek	0.0	0.0	0.2	0.2	43.9	0.0	0.0	0.0	0.0	0.0	0.0	0.4	43.9	0.0	44.3	0.0
119	**02040206120**	Still Run / Little Ease Run	0.9	0.1	0.9	0.0	0.0	2.2	0.2	0.0	0.0	0.0	0.0	3.6	0.4	0.2	4.1	0.0
118	**02040206130**	Scotland Run	2.3	0.0	1.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0	3.3	0.0
128	**02040206140**	Maurice River (above Sherman Ave Bridge)	8.5	0.0	1.2	1.3	0.0	3.3	0.0	0.0	0.0	0.0	0.0	13.0	0.0	0.0	13.0	0.0
126	**02040206150**	Muddy Run	0.1	0.2	0.7	0.1	0.0	10.6	0.6	0.3	0.2	0.0	0.0	10.6	1.0	0.7	12.3	0.0
135	**02040206160**	Maurice River (Union Lk to Sherman Ave)	0.6	0.0	0.4	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.9	4.3	0.0
142	**02040206170**	Maurice River (Menantico Ck to Union Lk)	3.2	0.0	0.4	0.2	0.0	2.2	0.0	0.0	0.0	0.0	0.0	5.5	0.0	0.0	5.5	0.0
132	**02040206180**	Menantico Creek	1.7	0.0	0.6	0.7	4.6	7.2	0.3	0.1	0.0	0.0	0.0	9.3	4.9	0.5	14.8	0.0
136	**02040206190**	Manamuskin River	0.2	0.0	0.3	0.1	0.0	1.9	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.1	2.3	0.0
146	**02040206200**	Maurice River (below Menantico Creek)	0.0	0.0	0.4	1.0	8.8	0.0	0.0	0.0	0.0	0.0	0.0	1.2	8.8	1.1	11.1	0.0

Table 17D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
141	**02040204910**	Delaware Bay (Cape May Pt to Fishing Ck)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
114	**02040206020**	Pennsville / Penns Grove tribs	0.0	1.1	1.1	0.1	1.4	0.0	0.0	0.0	0.0	0.0	1.4	0.0	2.9	1.1	4.0

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
117	**02040206030**	Salem R (above 39d40m14s dam)/ Salem Canal	0.0	0.4	0.0	0.5	0.0	8.0	0.1	0.4	0.0	0.0	0.0	0.0	0.6	8.9	9.4
124	**02040206040**	Salem River (below 39d40m14s dam)	0.0	0.0	0.6	0.3	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.3	0.2	0.5
127	**02040206060**	Alloway Creek / Hope Creek	0.0	0.0	0.0	0.6	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.7
133	**02040206070**	Stow Creek	0.0	0.0	0.0	0.1	0.0	0.9	0.1	0.1	0.0	0.0	0.0	0.0	0.2	1.0	1.1
129	**02040206080**	Cohansey River (above Sunset Lake)	0.0	0.0	0.0	0.6	4.3	0.0	1.0	0.1	0.0	0.0	0.0	0.0	5.9	0.1	6.0
139	**02040206090**	Cohansey River (below Cornwell Run)	0.0	2.7	0.0	0.9	0.0	1.3	0.7	0.1	0.0	0.0	0.0	0.0	1.7	4.1	5.8
144	**02040206100**	Back / Cedar / Nantuxent Creeks	0.0	0.0	0.0	0.3	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.8
147	**02040206110**	Dividing Creek	0.0	0.0	0.0	0.2	0.2	41.3	0.0	0.0	0.0	0.0	0.0	0.0	0.4	41.3	41.7
119	**02040206120**	Still Run / Little Ease Run	0.0	0.0	0.0	0.7	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.9
118	**02040206130**	Scotland Run	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.8
128	**02040206140**	Maurice River (above Sherman Ave Bridge)	0.0	0.0	0.0	0.9	1.2	0.0	0.3	0.0	0.0	0.0	0.0	0.0	2.4	0.0	2.4
126	**02040206150**	Muddy Run	0.0	0.0	0.0	0.5	0.1	0.0	1.1	0.1	0.0	0.0	0.0	0.0	1.7	0.1	1.8
135	**02040206160**	Maurice River (Union Lk to Sherman Ave)	0.0	0.0	0.0	0.3	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.6
142	**02040206170**	Maurice River (Menantico Ck to Union Lk)	0.0	0.0	2.2	0.3	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.7
132	**02040206180**	Menantico Creek	0.0	0.0	0.0	0.4	0.6	4.1	0.7	0.0	0.0	0.0	0.0	0.0	1.8	4.2	6.0
136	**02040206190**	Manamuskin River	0.0	0.0	0.0	0.2	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5
146	**02040206200**	Maurice River (below Menantico Creek)	0.0	0.0	0.0	0.3	0.9	8.3	0.0	0.0	0.0	0.0	0.0	0.0	1.2	8.3	9.5

Notes (applicability may vary by WMA)

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.
3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.
4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.
5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

WATERSHED MANAGEMENT AREA 18

LOWER DELAWARE

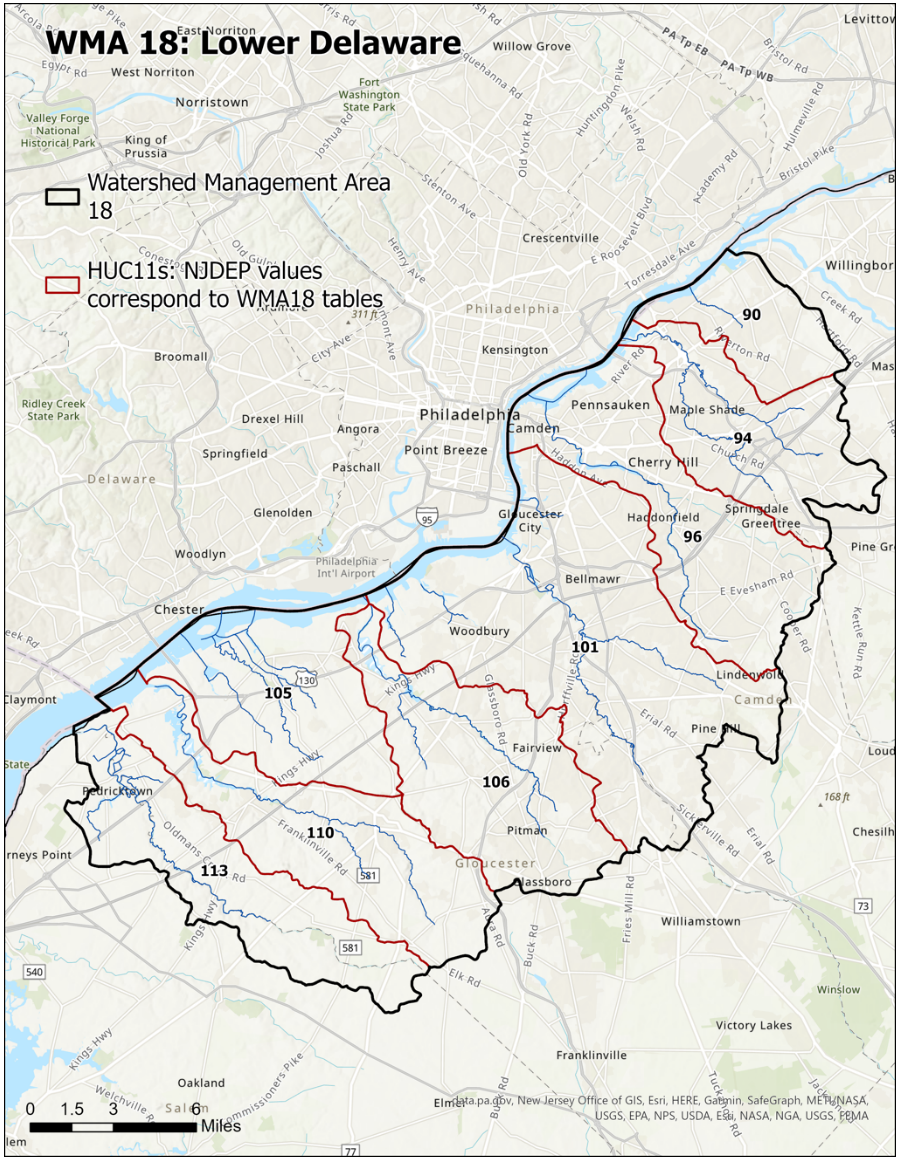

Table 18A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
90	**02040202090**	Pompeston Creek / Swede Run	19.8	18.5	4.0	1.4	25%	2.5						0	
94	**02040202100**	Pennsauken Creek	36.4	36.2	9.8	4.4	25%	5.4						0	
96	**02040202110**	Cooper River	51.3	48.5	18.2	8.9	25%	9.3						8	
101	**02040202120**	Woodbury / Big Timber / Newton Creeks	98.9	95.7	71.3	43.3	25%	28.0						0	
106	**02040202130**	Mantua Creek	50.2	50.1	26.2	11.5	25%	14.7						0	
105	**02040202140**	Cedar Swamp / Repaupo Ck / Clonmell Ck	41.0	35.8	20.0	6.7	25%	13.3						0	
110	**02040202150**	Raccoon Creek / Birch Creek	49.7	48.4	21.4	9.9	25%	11.5						0	
113	**02040202160**	Oldmans Creek	44.0	43.9	16.1	6.7	25%	9.4						8	

Table 18B. Summary of HUC11 Remaining Available Water and Full Allocation

					Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
90	**02040202090**	Pompeston Creek / Swede Run	2017	0.6	-0.3	Net Gain	1.0	0.4	62%	0.2	Con Aq Leak	100%	Potable	100%
94	**02040202100**	Pennsauken Creek	2014	1.4	-0.4	Net Gain	1.8	-0.3	Net Gain	1.7	Con Aq Leak	100%	Potable	87%
96	**02040202110**	Cooper River	2020	2.3	8.0	346%	0.0	10.4	447%	0.0	Potable	100%	Potable	100%

DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
					Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
101	**02040202120**	Woodbury / Big Timber / Newton Creeks	2016	7.0	-57.2	Net Gain	64.2	-58.8	Net Gain	65.8	Con Aq Leak	57%	Potable	52%
106	**02040202130**	Mantua Creek	2018	3.7	2.9	80%	0.7	5.4	146%	0.0	Con Aq Leak	50%	Potable	100%
105	**02040202140**	Cedar Swamp / Repaupo Ck / Clonmell Ck	2014	3.3	1.0	31%	2.3	6.2	188%	0.0	Con Aq Leak	38%	Ag/Irr	100%
110	**02040202150**	Raccoon Creek / Birch Creek	2017	2.9	2.1	73%	0.8	9.2	318%	0.0	Ag/Irr	55%	Ag/Irr	100%
113	**02040202160**	Oldmans Creek	2013	2.4	3.9	164%	0.0	12.8	543%	0.0	Ag/Irr	100%	Ag/Irr	100%

Table 18C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/ Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
90	**02040202090**	Pompeston Creek / Swede Run	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	1.2	1.4	0.0
94	**02040202100**	Pennsauken Creek	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	4.1	4.2	0.0
96	**02040202110**	Cooper River	4.5	0.0	0.2	0.1	0.9	0.0	0.0	0.2	0.1	0.0	0.0	4.4	1.1	3.7	9.2	0.0
101	**02040202120**	Woodbury / Big Timber / Newton Creeks	2.2	0.0	0.4	0.1	0.0	0.1	0.0	0.1	0.8	0.0	0.0	2.7	0.8	4.0	7.6	0.0
106	**02040202130**	Mantua Creek	0.5	0.0	0.5	0.1	0.2	0.2	0.4	0.0	0.1	0.0	0.0	1.2	0.7	1.9	3.8	0.0
105	**02040202140**	Cedar Swamp / Repaupo Ck / Clonmell Ck	0.8	0.1	0.2	0.4	0.4	0.3	0.3	0.0	0.0	0.0	0.0	1.6	0.8	1.3	3.7	0.0
110	**02040202150**	Raccoon Creek / Birch Creek	1.0	0.0	1.3	0.0	0.0	0.4	1.4	0.0	0.0	0.0	0.0	2.4	1.4	1.4	5.2	0.0

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
113	**02040202160**	Oldmans Creek	0.0	0.0	0.5	0.0	0.0	1.8	1.8	0.0	0.0	0.0	0.0	2.1	1.8	0.9	4.8	0.0

Table 18D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
90	**02040202090**	Pompeston Creek / Swede Run	0.0	1.6	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.6	1.7
94	**02040202100**	Pennsauken Creek	0.0	4.5	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	4.5	4.7
96	**02040202110**	Cooper River	0.0	0.0	0.0	0.1	0.1	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.9	1.1
101	**02040202120**	Woodbury / Big Timber/ Newton Creeks	0.0	63.4	0.0	0.3	0.9	0.0	0.0	0.0	0.0	0.1	0.0	0.0	1.3	63.5	64.8
106	**02040202130**	Mantua Creek	0.0	0.0	0.0	0.4	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.6	0.2	0.9
105	**02040202140**	Cedar Swamp / Repaupo Ck / Clonmell Ck	0.0	0.4	0.0	0.2	1.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.8	2.6
110	**02040202150**	Raccoon Creek / Birch Creek	0.0	1.7	0.0	0.9	0.2	0.0	0.1	0.1	0.0	0.0	0.0	0.0	1.2	1.9	3.1
113	**02040202160**	Oldmans Creek	0.0	0.0	0.0	0.4	0.1	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.8	0.2	1.0

Notes (applicability may vary by WMA)

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.
3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.
4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.
5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

WATERSHED MANAGEMENT AREA 19

RANCOCAS

Table 19A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
93	**02040202020**	Rancocas Creek NB (above New Lisbon dam)	32.1	32.1	17.7	7.0	25%	10.6						0	
97	**02040202030**	Greenwood Branch (NB Rancocas Creek)	78.2	78.1	31.3	13.7	25%	17.6						0	
92	**02040202040**	Rancocas Creek NB (below New Lisbon dam)	37.7	147.9	17.7	7.4	25%	10.4						0	
98	**02040202050**	Rancocas Creek SB (above Bobbys Run)	68.6	144.6	20.5	6.1	25%	14.4			Yes			0	
100	**02040202060**	Rancocas Creek SB SW Branch	76.0	76.0	26.8	12.9	25%	13.9						0	
95	**02040202070**	Rancocas Creek SB (below Bobbys Run)	22.6	167.1	4.7	1.7	25%	3.0						0	
88	**02040202080**	Rancocas Creek	35.6	349.7	6.9	2.7	25%	4.2						0	

Table 19B. Summary of HUC11 Remaining Available Water and Full Allocation

					Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
93	**02040202020**	Rancocas Creek NB (above New Lisbon dam)	2014	2.7	1.2	46%	1.4	4.1	153%	0.0	Potable	35%	Potable	100%

DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
					Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
97	**02040202030**	Greenwood Branch (NB Rancocas Creek)	2020	4.4	0.7	16%	3.7	9.7	219%	0.0	Com/Ind/Min	11%	Potable	100%
92	**02040202040**	Rancocas Creek NB (below New Lisbon dam)	2017	2.6	-2.5	Net Gain	5.1	-0.7	Net Gain	3.2	Con Aq Leak	36%	Ag/Irr	89%
98	**02040202050**	Rancocas Creek SB (above Bobbys Run)	2014	3.6	3.2	88%	0.4	9.2	254%	0.0	Ag/Irr	79%	Ag/Irr	100%
100	**02040202060**	Rancocas Creek SB SW Branch	2016	3.5	0.9	26%	2.6	1.8	51%	1.7	Con Aq Leak	61%	Non-Ag Irr	15%
95	**02040202070**	Rancocas Creek SB (below Bobbys Run)	2015	0.7	0.6	81%	0.1	0.9	126%	0.0	Con Aq Leak	76%	Potable	100%
88	**02040202080**	Rancocas Creek	2016	1.1	-7.2	Net Gain	8.2	-7.3	Net Gain	8.3	Con Aq Leak	100%	Potable	53%

Table 19C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/ Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
93	**02040202020**	Rancocas Creek NB (above New Lisbon dam)	0.0	0.9	0.2	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.2	2.2	0.3	2.6	0.0

DEP Value	HUC11	HUC11 Name	Public Supply UnGW	Public Supply Non-RSW SW	Domestic UnGW	Com/Ind/Min UnGW	Com/Ind/Min SW	Ag/Irr UnGW	Ag/Irr SW	Non-Ag Irr UnGW	Non-Ag Irr SW	Power Gen UnGW	Power Gen SW	Combined SFD Adj UnGW	Combined SW	Combined Leakage	Combined Total	RSW Withdrawals
97	**02040202030**	Greenwood Branch (NB Rancocas Creek)	0.1	0.0	0.6	0.0	5.5	0.0	1.3	0.0	0.0	0.0	0.0	0.7	6.9	0.0	7.5	0.0
92	**02040202040**	Rancocas Creek NB (below New Lisbon dam)	0.0	0.0	0.4	0.0	0.0	0.1	0.9	0.0	0.0	0.0	0.0	0.4	0.9	0.9	2.3	0.0
98	**02040202050**	Rancocas Creek SB (above Bobbys Run)	0.1	0.0	0.5	0.0	0.1	0.7	3.4	0.0	0.0	0.0	0.0	1.1	3.5	0.4	5.0	0.0
100	**02040202060**	Rancocas Creek SB SW Branch	0.0	0.1	1.9	0.0	0.0	0.8	0.5	0.0	0.4	0.0	0.0	2.5	0.9	2.1	5.6	0.0
95	**02040202070**	Rancocas Creek SB (below Bobbys Run)	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.6	0.7	0.0
88	**02040202080**	Rancocas Creek	0.0	0.0	0.2	0.1	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.5	0.2	1.3	2.0	0.0

Table 19D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer UnGW	Sanitary Sewer SW Fresh	Sanitary Sewer SW Saline	Domestic Septic	Com/Ind/Min UnGW	Com/Ind/Min SW	Ag/Irr UnGW	Ag/Irr SW	Non-Ag Irr UnGW	Non-Ag Irr SW	Power Gen UnGW	Power Gen SW	Combined UnGW	Combined SW	Combined Total
93	**02040202020**	Rancocas Creek NB (above New Lisbon dam)	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.1	1.3	1.4
97	**02040202030**	Greenwood Branch (NB Rancocas Creek)	0.0	0.0	0.0	0.4	0.0	5.1	0.0	1.3	0.0	0.0	0.0	0.0	0.4	6.4	6.8
92	**02040202040**	Rancocas Creek NB (below New Lisbon dam)	0.0	4.3	0.0	0.3	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.3	4.4	4.8
98	**02040202050**	Rancocas Creek SB (above Bobbys Run)	0.1	0.3	0.0	0.3	0.0	0.1	0.2	1.0	0.0	0.0	0.0	0.0	0.6	1.3	1.9
100	**02040202060**	Rancocas Creek SB SW Branch	0.0	3.0	0.0	1.4	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	1.6	3.1	4.7

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
95	**02040202070**	Rancocas Creek SB (below Bobbys Run)	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
88	**02040202080**	Rancocas Creek	0.0	8.8	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	8.8	9.2

Notes (applicability may vary by WMA)

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.
3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.
4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.
5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

WATERSHED MANAGEMENT AREA 20

ASSISCUNK, CROSSWICKS, AND DOCTORS

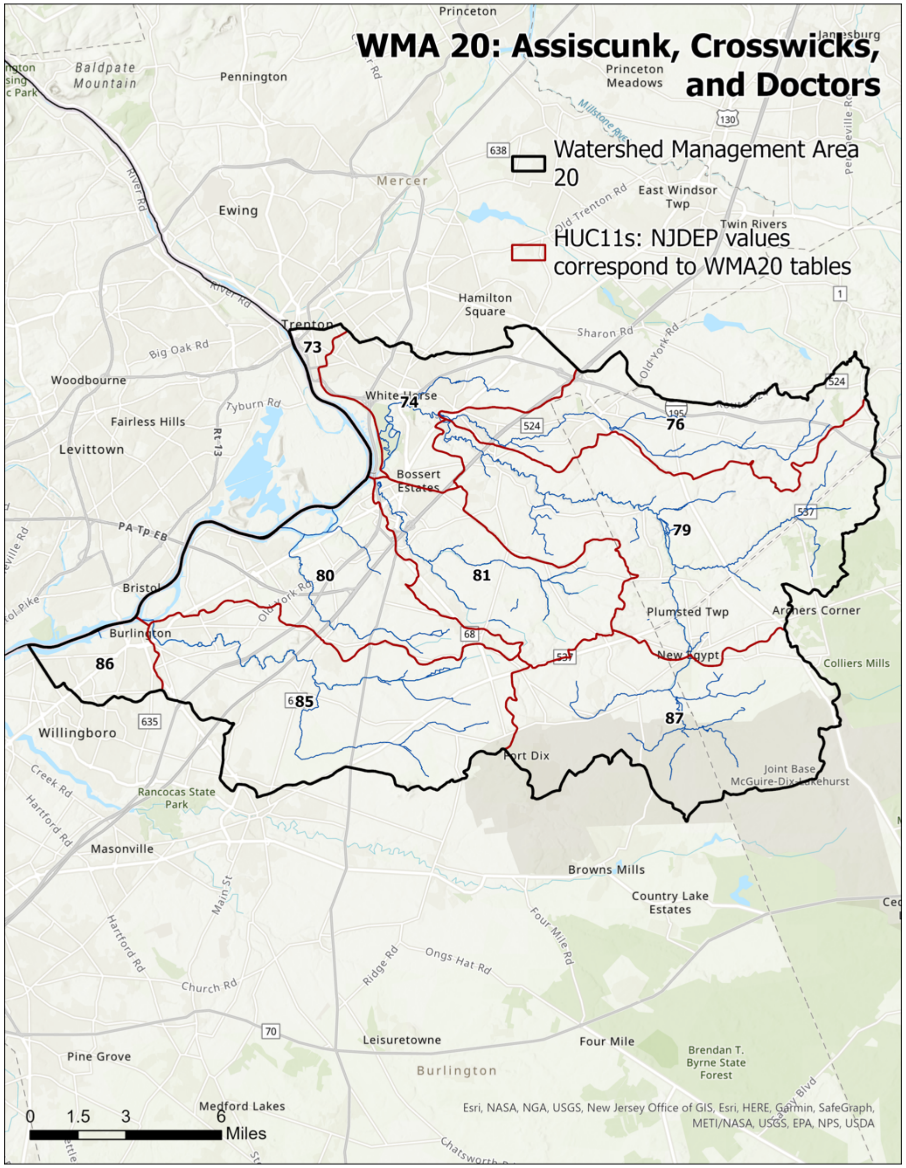

Table 20A. Summary of HUC11 Area, Low Flow Margin, and Water Availability Considerations

DEP Value	HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	September Median Flow (mgd)	7Q10 (mgd)	LFM Percentage	LFM (mgd)	NJ Highlands[2]	Major SW Potable Supply[3]	Potentially 7Q10 Limited [4]	Lim. Avail. HUC Upstream	In a Stressed WMA	Number of Stressed 3-Yr Periods	Has Saline Discharge
73	**02040201030**	Duck Creek and UDRV to Assunpink Ck	3.3	2.7	0.3	0.1	25%	0.2						0	
87	**02040201040**	Crosswicks Ck (above New Egypt)	41.2	41.2	17.8	8.1	25%	9.7						0	
79	**02040201050**	Crosswicks Ck (Doctors Ck to New Egypt)	57.0	98.2	21.1	9.2	25%	11.9						0	
76	**02040201060**	Doctors Creek	25.9	25.9	7.4	2.2	25%	5.1			Yes			0	
74	**02040201070**	Crosswicks Ck (below Doctors Creek)	20.1	144.2	3.6	1.2	25%	2.4						0	
81	**02040201080**	Blacks Creek	23.4	23.4	5.8	2.0	25%	3.8						0	
80	**02040201090**	Crafts Creek	28.9	25.9	2.6	0.6	25%	2.1			Yes			0	
85	**02040201100**	Assiscunk Creek	45.9	45.9	5.1	1.5	25%	3.6			Yes			0	
86	**02040201110**	Burlington/ Edgewater Park Delaware tribs	7.2	6.6	1.4	0.5	25%	0.8						0	

Table 20B. Summary of HUC11 Remaining Available Water and Full Allocation

					Current			Full Allocation (F.A.)			Largest Dep-Con Loss			
DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Net Dep-Con (mgd)	% Available Used	Remaining Available Water (mgd)	Largest Loss Current Use	Largest Loss % Available Water (Current)	Largest Loss F.A. Use	Largest Loss % Available Water (F.A.)
73	**02040201030**	Duck Creek and UDRV to	2017	0.1	-9.7	Net Gain	9.8	0.0	1%	0.1	Minimal Loss	0%	Potable	N/A

DEP Value	HUC11	HUC11 Name	Peak Year With.[5]	Available Water (mgd)	Current: Net Dep-Con (mgd)	Current: % Available Used	Current: Remaining Available Water (mgd)	Full Allocation (F.A.): Net Dep-Con (mgd)	Full Allocation (F.A.): % Available Used	Full Allocation (F.A.): Remaining Available Water (mgd)	Largest Dep-Con Loss: Largest Loss Current Use	Largest Dep-Con Loss: Largest Loss % Available Water (Current)	Largest Dep-Con Loss: Largest Loss F.A. Use	Largest Dep-Con Loss: Largest Loss % Available Water (F.A.)
		Assunpink Ck												
87	**02040201040**	Crosswicks Ck (above New Egypt)	2017	2.4	1.2	52%	1.2	1.6	65%	0.9	Con Aq Leak	35%	Potable	20%
79	**02040201050**	Crosswicks Ck (Doctors Ck to New Egypt)	2016	3.0	1.9	63%	1.1	10.0	336%	0.0	Ag/Irr	41%	Ag/Irr	100%
76	**02040201060**	Doctors Creek	2020	1.3	0.6	44%	0.7	3.8	293%	0.0	Con Aq Leak	33%	Ag/Irr	100%
74	**02040201070**	Crosswicks Ck (below Doctors Creek)	2018	0.6	-4.7	Net Gain	5.3	-3.3	Net Gain	3.9	Con Aq Leak	63%	Potable	72%
81	**02040201080**	Blacks Creek	2017	0.9	0.0	5%	0.9	4.3	458%	0.0	Ag/Irr	90%	Ag/Irr	100%
80	**02040201090**	Crafts Creek	2020	0.5	-0.2	Net Gain	0.7	-0.5	Net Gain	1.0	Con Aq Leak	96%	Potable	37%
85	**02040201100**	Assiscunk Creek	2016	0.9	0.9	98%	0.0	1.7	194%	0.0	Con Aq Leak	58%	Ag/Irr	100%
86	**02040201110**	Burlington/ Edgewater Park Delaware tribs	2020	0.2	-2.3	Net Gain	2.5	-2.9	Net Gain	3.1	Con Aq Leak	26%	Potable	100%

Table 20C. Summary of HUC11 Withdrawals in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/ Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
73	**02040201030**	Duck Creek and UDRV to Assunpink Ck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DEP Value	HUC11	HUC11 Name	Public Supply		Domestic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined				RSW Withdrawals
			UnGW	Non-RSW SW	UnGW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	SFD Adj UnGW	SW	Leakage	Total	
87	**02040201040**	Crosswicks Ck (above New Egypt)	0.0	0.0	0.4	0.0	0.3	0.0	0.5	0.0	0.0	0.0	0.0	0.4	0.7	0.8	2.0	0.0
79	**02040201050**	Crosswicks Ck (Doctors Ck to New Egypt)	0.0	0.0	1.1	0.0	0.0	0.5	1.0	0.0	0.2	0.0	0.0	1.4	1.1	1.0	3.6	0.0
76	**02040201060**	Doctors Creek	0.0	0.0	0.2	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.2	0.3	0.4	0.9	0.0
74	**02040201070**	Crosswicks Ck (below Doctors Creek)	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.4	2.1	0.0
81	**02040201080**	Blacks Creek	0.0	0.0	0.7	0.0	0.0	0.1	0.9	0.0	0.0	0.0	0.0	0.7	1.0	0.2	1.9	0.0
80	**02040201090**	Crafts Creek	0.8	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.5	1.7	0.0
85	**02040201100**	Assiscunk Creek	0.0	0.0	0.4	0.0	0.0	0.2	0.2	0.0	0.1	0.0	0.0	0.6	0.3	0.5	1.4	0.0
86	**02040201110**	Burlington/ Edgewater Park Delaware tribs	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.1	1.0	0.0

Table 20D. Summary of HUC11 Discharges in Millions of Gallons per Day (mgd)

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
73	**02040201030**	Duck Creek and UDRV to Assunpink Ck	0.0	9.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.7	9.7
87	**02040201040**	Crosswicks Ck (above New Egypt)	0.0	0.1	0.0	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.8
79	**02040201050**	Crosswicks Ck (Doctors Ck to New Egypt)	0.0	0.7	0.0	0.8	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.9	0.8	1.7
76	**02040201060**	Doctors Creek	0.0	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.4
74	**02040201070**	Crosswicks Ck (below Doctors Creek)	0.0	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8	6.9
81	**02040201080**	Blacks Creek	0.0	1.1	0.0	0.5	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.6	1.2	1.8
80	**02040201090**	Crafts Creek	0.0	1.3	0.0	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.3	1.9
85	**02040201100**	Assiscunk Creek	0.0	0.2	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.5

DEP Value	HUC11	HUC11 Name	Sanitary Sewer			Domestic Septic	Com/Ind/Min		Ag/Irr		Non-Ag Irr		Power Gen		Combined		
			UnGW	SW Fresh	SW Saline		UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	UnGW	SW	Total
86	**02040201110**	Burlington/Edgewater Park Delaware tribs	0.0	3.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	3.2	3.3

Notes (applicability may vary by WMA)

1. There are some watersheds upstream of WMA where depletive and consumptive uses are occurring, but this analysis does not account for out of state water use.
2. New or increased diversions within HUC11s located completely or partially within the Highlands will be addressed on a case-by-case basis in cooperation with the Highlands Council.
3. New or increased diversions upstream of potable supply reservoirs or intakes must quantify and offset any reduction to the system's safe yield.
4. The HUC11 LFM method available water exceeds 50% of the 7Q10. Additional availability analysis required.
5. Peak Year With. represents the final year of the 3-year period with the highest average withdrawals.

State of New Jersey
Department of Environmental Protection

2024 NEW JERSEY STATEWIDE WATER SUPPLY PLAN

APPENDIX B

SURFACE WATER SYSTEMS OF NEW JERSEY

SURFACE WATER SYSTEMS OF NEW JERSEY

Table of Contents

The following section describes the major surface water reservoirs systems in New Jersey by drought region.

NORTHEAST DROUGHT REGION

NORTH JERSEY DISTRICT WATER SUPPLY COMMISSION

North Jersey District Water Supply Commission (NJDWSC) operates the Wanaque Reservoir, Ramapo pumping station, and Monksville/Wanaque South – Two Bridges Pump Station as one system. The Wanaque Reservoir, completed in 1929, is located in northeastern New Jersey, directly above the town of Pompton Lakes on the Wanaque River. In 1987, construction was completed on the Monksville Reservoir, also located on the Wanaque River, and just upstream of the Wanaque Reservoir, which culminated in total reservoir storage of 36.6 bg.

The NJDWSC reservoirs, Wanaque (29.6 bg) and Monksville (7.0 bg), are filled from three sources. The first source is the Wanaque River. Both Wanaque and Monksville are “on-stream” reservoirs on the Wanaque River. The Wanaque Reservoir, with a 94.4 square mile drainage area and a storage capacity of 29.6 bg, has a 10 mgd passing flow requirement downstream on the Wanaque River. The second source is the Ramapo River. The NJDWSC operates a pump station on the Ramapo River that can pump approximately 150 mgd of water into the Wanaque Reservoir, provided a 40 mgd passing flow requirement is maintained downstream of the pump station. The third source available is the Wanaque South -Two Bridges Pump Station, which consists of a single intake located on the Pompton River, upstream of the confluence of the Pompton and Passaic Rivers. From this pump station, six pumps can divert up to 250 mgd of water into the Wanaque Reservoir or into the Oradell Aqueduct, provided a minimum passing flow of 92.6 mgd is maintained in the Passaic River and required temperature and dissolved oxygen levels are met.

The NJDWSC consists of 13 member municipalities and water systems. The current approved safe yield of 190 mgd is distributed as follows:

Table B1. North Jersey District Water Supply Commission Allocations

Municipality	Daily Allocation of Currently Approved Safe Yield (mgd)
Bayonne	10.5
Bloomfield	7.51
Cedar Grove	1.2
Clifton (PVWC)	6.345
Glen Ridge	0.705
Kearny	13
Montclair	5.7
Patterson (PVWC)	18.8
Passaic (PVWC)	10.34
Newark	49.4
Nutley	3
Wayne	9.5

Table B2. North Jersey District Water Supply Commission Allocations

Municipality	Daily Allocation of Currently Approved Safe Yield (mgd)
Veolia- Hackensack municipalities	48

VEOLIA WATER NEW JERSEY

Veolia New Jersey serves water to Alpine, Bergenfield, Bogota, Carlstadt, Cliffside Park, Closter, Cresskill, Demarest, Dumont, East Rutherford, Edgewater, Emerson, Englewood, Englewood Cliffs, Fair Lawn, Fairview, Fort Lee, Franklin Lakes, Hackensack, Hasbrouck Heights, Haworth, Hillsdale, Leonia, Little Ferry, Lodi, Maywood, Montvale, Moonachie, New Milford, Northvale, Norwood, Old Tappan, Oradell, Palisades Park, Paramus, Ridgefield, Ridgefield Park, River Edge, River Vale, Rochelle Park, Rockleigh, Rutherford, Saddle Brook, South Hackensack, Teaneck, Tenafly, Teterboro, Upper Saddle River, Wallington, Washington Township, Westwood, Woodcliff Lake, Wood-Ridge, Guttenberg, Hoboken, North Bergen, Secaucus, Union City, Weehawken, West New York and other towns through wholesale contracts. In addition to water received through its co-ownership of the Wanaque South project with NJDWSC, Suez Water (previously United Water New Jersey-UWNJ) system consists of four reservoirs in the Hackensack River Basin, four surface water diversions (the Wanaque-South project and intakes on the Saddle River, Hirschfeld Brook and Sparkill Creek), and a series of groundwater wells. The combined storage of the four reservoirs is approximately 13.9 billion gallons (bg). The total safe yield of UWNJ system is 126.5 mgd.

The four Hackensack River Basin reservoirs are as follows:

- Lake Deforest Reservoir is located 0.8 miles north of West Nyack, Rockland County, New York. The reservoir has a drainage area of 27.5 square miles and storage capacity of 5.67 bg.[1] The importance of interstate agreements and cooperation is clear considering that Suez New Jersey is reliant upon this source, which is located in New York State.
- Lake Tappan, downstream of Lake Deforest, is located 0.5 miles north of Old Tappan in Bergen County. The reservoir has a drainage area of 49 square miles and a storage capacity of 3.853 bg.
- Woodcliff Lake is a dammed impoundment along Pascack Brook, a tributary to the Hackensack River. The Lake is located 0.7 miles north of Hillsdale in Bergen County. The reservoir has a drainage area of 19.4 square miles and storage capacity of 0.871 bg.
- The Oradell Reservoir is the terminal impoundment of the Suez New Jersey system and is located on the Hackensack River at Oradell in Bergen County. The reservoir has a drainage area of 113 square miles and a storage capacity of 3.507 bg.

As an equal partner in the Wanaque-South Project with the NJDWSC, Suez New Jersey currently receives up to 48.0 mgd of water via the Oradell Aqueduct, a 17-mile pipeline that connects NJDWSC's Wanaque system and Suez's Oradell Reservoir. Intakes and pump stations on the Saddle River, Hirshfeld Brook and Sparkill Creek can also be used to provide additional storage in the Oradell Reservoir.

[1] Located entirely in New York State, Lake DeForest principally is used to serve customers of Veolia NY. However, under a bi-state agreement and Veolia NY permitting conditions, minimal releases from Lake DeForest must be made under certain conditions to maintain flow in the Hackensack River. Finally, Veolia operates raw water wells which deliver water into nearby surface sources flowing into the Oradell Reservoir.

PASSAIC VALLEY WATER COMMISSION

The Passaic Valley Water Commission (PVWC) treats and supplies water to the towns of Passaic, Paterson, Clifton, Lodi, Elmwood Park, Prospect Park, Little Falls, West Paterson, and other communities through wholesale contracts. The PVWC operates three intakes on the Pompton and Passaic Rivers (Jackson Avenue, Two Bridges, and Little Falls), and an off-stream reservoir, known as Point View. The Jackson Avenue Pump Station on the Pompton River houses five pumps with a capacity of 10 mgd each. PVWC is permitted to divert 1,550 mgm from this intake to fill the Point View Reservoir, but must maintain a 136.2 cubic feet per second (cfs) passing flow at the United States Geological Survey (USGS) gaging station, located downstream of the Jackson Avenue diversion. The Point View Reservoir has a maximum storage capacity of 2.9 bg.

During times of low flow, releases are made from the reservoir to the Pompton River to ensure 75 mgd is available for diversion by PVWC at the Little Falls Pump Station and treatment plant. In addition, PVWC must maintain a minimum passing flow of 0.62 cfs for the Haycock Brook, immediately below the reservoir. The PVWC also operates intakes at the Two Bridges and Little Falls locations. They have two 50 mgd pumps in the Two Bridges Pump Station that divert water from the Pompton and Passaic Rivers. Water is transferred from Two Bridges to the Little Falls Treatment Plant via a 60-inch main. The Little Falls diversion is PVWC's farthest downstream diversion point, where three-60 mgd pumps divert water, via a canal off the Passaic River, to the treatment plant. The PVWC is permitted to divert up to 2,325 mgm from Two Bridges and/or Little Falls. PVWC is also a member of the NJDWSC and receives 34.485 mgd from that source.

CITY OF NEWARK

The City of Newark Water Department serves the City of Newark, Pequannock Township, the City of East Orange, Wayne Township, the Town of Bellville, the City of Elizabeth, and Bloomfield Township. The City of Newark's water sources lie within the Pequannock Watershed, in the Townships of Kinnelon, West Milford, Jefferson, Hardyston, and Vernon. The City of Newark also owns approximately 80% of the property surrounding its reservoirs. The five main reservoirs of the Newark system – Echo Lake, Canistear, Oak Ridge, Clinton, and Charlottesburg Reservoirs – are all located on the Pequannock River or its tributaries, and are all wholly reliant on gravity flow for storage. The combined storage of the five reservoirs is 14.80 bg, while the safe yield of the entire system is 49.1 mgd. Newark also receives 49.4 mgd from the NJDWSC system.

Newark's Pequannock System Reservoirs:

- Echo Lake Reservoir is located in Passaic County, 1.6 miles north of Charlottesburg and 1.9 miles upstream from the mouth of the Macopin River. The reservoir has a drainage area of 4.35 square miles including the Matthews Brook diversion and a storage capacity of 2.004 bg at spillway elevation.
- Canistear Reservoir is located in Sussex County, 1.8 miles northeast of Stockholm. It has a drainage area of 6.08 square miles and a storage capacity of 2.407 bg at spillway elevation.
- Oak Ridge Reservoir is located in Passaic County, at the dam of the Pequannock River, 0.9 miles southwest of Oak Ridge. The reservoir has a drainage area of 27.3 square miles and a storage capacity of 3.909 bg at spillway elevation.
- Clinton Reservoir is located in Passaic County, at the dam on Clinton Brook, 2.0 miles north of Newfoundland, New Jersey. It has a drainage area of 10.5 square miles and a storage capacity of 3.518 bg at spillway elevation.

- Charlottesburg Reservoir is located in Passaic County, 1.1 miles upstream from the Macopin River, and 1.5 miles southeast of Newfoundland, New Jersey. It has a drainage area of 56.2 square miles and has a storage capacity of 2.964 bg at spillway elevation with its bascule gate closed. This reservoir is where the Newark diversion is taken, consequently being the most downstream of the five reservoirs.

CITY OF JERSEY CITY

The Jersey City system is comprised of the Boonton Reservoir system and is owned by the City of Jersey City. Currently, operations of the Jersey City system have been granted to Suez under contract. The system supplies water to Jersey City, Caldwell, and Lyndhurst. The Boonton Reservoir System consists of two reservoirs located in the Rockaway River Watershed: Boonton Reservoir and Splitrock Reservoir. The system has a combined storage of 11.3 bg. The Boonton Reservoir is the southernmost of the two and is the point of diversion for the water system treatment plant. A 7.9 mgd minimum passing flow requirement must be satisfied in the Rockaway River, downstream of the reservoir diversion. The safe yield of the system is 56.8 mgd and consists of only natural water flow into the reservoirs.

NEW JERSEY AMERICAN WATER COMPANY – PASSAIC SYSTEM

New Jersey American Water Company's Passaic system serves the following: Bedminster, Berkeley Heights, Bernard, Bernardsville, Chatham, Chester, Far Hills, Livingston, Long Hill, Maplewood, Millburn, New Providence, Short Hills, Springfield, Summit, West Orange and portions of City of Orange, Florham Park, Harding, Hillside, Livingston, Mendham, South Orange, Union, Warren, and Watchung. The Passaic System consists of several groundwater wells, three surface water intakes and three off-stream reservoirs located in the upper Passaic River Basin. These reservoirs are called Number 1, 2 and 3. The combined storage of the three is 2.84 bg. The safe yield of the entire system is 10.8 mgd, which is fed mainly by water pumped from two surface water sources – Canoe Brook and Passaic River.

TAYLORTOWN RESERVOIR SYSTEM – TOWN OF BOONTON

The Town of Boonton and surrounding Boonton Township receive water from four groundwater wells and one surface water source, Taylortown Reservoir, sometimes referred to as Taylorsville Reservoir. The system serves Boonton Town, Boonton Township, Montville Township and Mountain Lakes Borough where it serves an approximate population of 9,000 people.

The reservoir is approximately 82 acres in area and had an approximate capacity of 125 million gallons when constructed in 1895 but subsequently been reduced to 75 million gallons. The Taylortown reservoir intake has a rated pump capacity of less than or equal to 1,400 gallons per minute or 2.016 mgd. Water from Taylortown Reservoir is pumped via two 20 HP centrifugal pumps, each 700 gallons per minute (gpm), into the treatment plant where it goes to the distribution system. The estimate safe yield of the reservoir itself as being 0.70 mgd as identified by work done in 1995 as part of the 1996 New Jersey Statewide Water Supply Plan. The applicable water allocation permit (WAP) limits for all diversion sources are 61.7 mgm and 575 mgy, while the monthly allocation limit for Taylortown Reservoir is 21.7 mgm and 250 mgy.

CLYDE POTTS RESERVOIR – SOUTHEAST MORRIS COUNTY MUA (SMCMUA)

Clyde Potts Reservoir is 15.6 mg and was created by an earth and concrete dam constructed in 1932 on Harmoney Brook and has a passing flow requirement of 0.13 cfs. The reservoir is located entirely within the Mendham Township boundaries, while about a third of the watershed supplying the reservoir surface waters is in the neighboring town of Randolph. The SMCMUA diverts surface water directly to

the treatment plant by a series of pumps totalizing 2,778 gpm. The reservoir has an allocation of 124 mgm and 795 mgy and serves an estimated population of approximately 63,000 people.

The SMCMUA system has interconnections with Morris County MUA, Parsippany-Troy Hills, New Jersey Psychiatric Institute, Randolph Township, East Hanover Township, Madison Borough, and The Borough of Florham Park and serves Hanover Township, Borough of Morris Plains, Morris Township, Morristown Township and portions of the Borough of Florham Park, Chatham Township, Harding Township, Randolph Township and Parsippany-Troy Hills.

KAKEOUT RESERVOIR – BOROUGH OF BUTLER RESERVOIR SYSTEM

Kakeout Reservoir (formerly Kikeout Reservoir) has a drainage basin of 5.61 square miles at the point of diversion and serves as a surface water supply reservoir system for Butler Borough, Passaic Valley Water Commission, Kinnelon Borough of Bloomingdale and the Borough of Riverdale, serving an approximately 9,650 people. The Reservoir consists of Kakeout Dam which is a diaphragm earthen fill embankment dam approximately 30 feet high and 410 feet long with a concrete core wall with a minimum 2-foot thickness extending into the underlying rock and glacial till foundation having a base width of 4 feet. This structure is owned, maintained, and operated by the Butler Water Company. The downstream passing flow below dam is 0.261 cfs. Water is diverted by gravity flow from the reservoir to the treatment plant and a permitted water allocation of 124 mgm and 1488 mgy at a maximum diversion rate of 2800 gpm.

NORTHWEST DROUGHT REGION

MORRIS LAKE (NEWTON RESERVOIR) – NEWTON TOWN WATER UTILITY

Morris Lake, also known as Newton Reservoir, is in Sparta Township in the Sparta Mountains in Sussex County, New Jersey. It has been the source of drinking water for the Town of Newton since the early 1900's. Originally Morris Lake was a deep, natural lake that covered 130 acres and was fed mainly by natural springs with a drainage area of about 1.25 square miles. In the mid-1800s, another dam was built approximately 0.25 mile below the lake, which formed a pond between the lake and Pine Swamp Brook. Eventually the pond and the lake were united when the pond was raised to the level of the first dam located at the original outlet of Morris Lake. Through damming a portion of Pine Swamp Brook, an artificial channel and smaller artificial lake were created below Morris Lake, which is now known as Glen Lake. The drainage area of these two lakes combined was increased to about 3.80 mi^2. Recent studies and surveys of the lake show a maximum depth of 119 feet and an average depth of 42 feet. The capacity of the reservoir as full spillway elevation in 1.98 bg with a corresponding surface area of 145 acres. The water system has a storage capacity of 2.0 mg and allocation amounts of 38.75 mgm and 393 mgy which serves a population of approximately 8,300 people.

CENTRAL DROUGHT REGION

NEW JERSEY WATER SUPPLY AUTHORITY

The New Jersey Water Supply Authority (NJWSA) owns and operates a surface water supply complex that indirectly supplies a large quantity of water to customers in Middlesex, Hunterdon, Mercer, Somerset, and Union. This complex is composed of three facilities: Spruce Run Reservoir, Round Valley Reservoir, and the Delaware & Raritan (D&R) Canal.

SPRUCE RUN AND ROUND VALLEY RESERVOIRS

Spruce Run Reservoir is located on the Spruce Run just north of Clinton, New Jersey. It has a drainage area of 41 square miles and a storage capacity of 11 bg. It is filled through natural flow from its two largest tributaries – Spruce Run and Mulhockaway Creek – and discharges into the South Branch of the Raritan River near Clinton. Statutory passing flows of 40 mgd at the USGS gaging station at Stanton and 70 mgd at the USGS stream gage at Manville are required.

Round Valley Reservoir is located just east of Spruce Run Reservoir. It has a storage capacity of 55 bg and is almost entirely reliant on water pumped from the South Branch of the Raritan River at the Hamden Pumping Station since its drainage area is a mere 5.7 square miles. Water can be released as needed to either the Hamden Pumping Station or the South Branch of Rockaway Creek (a tributary of the Lamington River) by gravity lines.

Water released from either reservoir travels downstream to maintain flow at the intake of New Jersey American Water/Elizabethtown Water Company and at the intakes of other users. There is also a required statutory passing flow of 90 mgd at the USGS stream gage at Bound Brook.

The Spruce Run and Round Valley systems have a safe yield of 176 mgd at Bound Brook. This, in combination with the D&R Canal safe yield of 65 mgd provides the NJWSA with a total yield of 241 mgd.

DELAWARE AND RARITAN CANAL

Originally constructed in 1834 as a barge canal, the Delaware & Raritan Canal (D&R Canal) underwent extensive rehabilitation by the New Jersey Water Supply Authority in the 1980’s. The D&R Canal is now operated to transfer water from the Delaware River into the Raritan River Basin for consumption. The feeder canal extends 22 miles along the Delaware River from Bull’s Island, near Frenchtown, south to Trenton. The main canal runs 36 miles from Trenton to New Brunswick with a break at the Route 1 crossing.

The NJWSA is allocated up to 100 mgd of Delaware River water via the D&R Canal, although under the “1983 Good Faith Agreement” of the Delaware River Basin Commissioners, only 65 million gallons per day may be diverted during a Drought Warning or Emergency designated by the Delaware River Basin Commission. This potential reduction in allocation is currently reflected in the safe yield of the NJWSA System. Under the Flexible Flow Management Plan (FFMP), the Parties to the 1954 Supreme Court decree agreed to temporarily re-establish a portion of the allotment to 85 mgd under drought conditions.

Water in the D&R Canal is transported by gravity flow through Hunterdon, Mercer, and Somerset Counties along the path of the Millstone River to the Raritan River. Most of the safe yield of the system is diverted by purveyors at Bound Brook. At Bound Brook, the Raritan River, containing water released upstream from the Spruce Run and Round Valley Reservoirs, is directly adjacent to the D&R Canal, containing the Delaware River water. A pump station located at this point is able to transfer water between the Raritan River and D&R Canal.

COASTAL NORTH DROUGHT REGION

NEW JERSEY WATER SUPPLY AUTHORITY – MANASQUAN RESERVOIR

The New Jersey Water Supply Authority’s Manasquan Reservoir supplies water directly or indirectly to the following: Avon-by-the-Sea, Belmar, Brielle, Keyport, Lake Como, Matawan, Red Bank, Sea Girt, Spring Lake, Spring Lake Heights, Wall Township and New Jersey American Water. The Manasquan Reservoir is located entirely within the Manasquan River drainage basin in southeastern Monmouth County and

northeastern Ocean County. It is located on Timber Swamp Brook, which is a tributary of the Manasquan River. The reservoir has a usable capacity of 4.67 bg and a 740-acre surface water body area, while having a safe yield of 30 mgd. The drainage area above the reservoir on Timber Swamp Brook is approximately 3.3 square miles, while the drainage area above the reservoir intake on the Manasquan River is approximately 65 square miles. The intake for the reservoir is located on the Manasquan River at Hospital Road, less than a half-mile west of the Garden State Parkway in Wall Township. The intake utilizes five intake pumps of which four can divert 40 mgd and one capable of diverting 20 mgd. The minimum passing flow on Timber Swamp Brook is 0.969 mgd, while the minimum passing flow below the intake on the Manasquan River is 8 mgd or 12 cfs.

Surface water is diverted from the Manasquan River or Manasquan Reservoir. The raw water can be diverted either to the NJAWC – Glendola Reservoir (described below), Oak Glenn Treatment Plant, or to the NJWSA Manasquan Treatment Plant for treatment and distribution, with excess returning to the Manasquan River aiding the 8 mgd or 12 cfs passing flow below the intake.

The Manasquan Water Treatment Plant is located on Hospital Road in the Allenwood section of Wall Township and is owned by the Monmouth County Improvement Authority but is operated by the NJWSA. This plant provides water used by residents in Brielle, Sea Girt, Spring Lake, Spring Lake Heights, and Wall Township.

NEW JERSEY AMERICAN WATER COMPANY – COASTAL NORTH SYSTEM – SWIMMING RIVER AND GLENDOLA RESERVOIRS

New Jersey American Water Company's (NJAWC) Coastal North System serves over 350,000 people within Monmouth and Ocean Counties. In addition to many groundwater wells, they divert water from intakes on the Jumping Brook and the Shark River and operate the Swimming River and Glendola reservoirs. The Swimming River Reservoir has a storage capacity of 2.3 bg, but only a usable capacity of 1.82 bg. Its drainage area is 48.5 square miles. The Swimming River Reservoir is fed by the Ramanessin Brook, Fourth Creek, Bordens Brook, Willow Brook, Hopp Brook, Big Brook, Fulling Mill Brook, Barren Neck Brook, Trout Brook, Yellow Brook, Miry Bog Brook, Mine Brook, Slope Brook, Hockhockson Brook, and Pine Brook. These tributaries allow the Swimming River to meet its passing flow of 9.4 cfs (or 6 mgd) below the reservoir.

The Glendola Reservoir is operated as an "off-river" storage facility to provide storage for flows pumped from the Shark River and Jumping Brook. The property is located in the Glendola section of Wall Township. The reservoir has a drainage area of 16.0 square miles and a storage capacity of 1 billion gallons. It maintains passing flows of 1.25 mgd in the Shark River and 0.75 mgd in the Jumping Brook. The reservoir has a safe yield of 11.1 mgd, inclusive of the 5.4 mgd purchased from the New Jersey Water Supply Authority Manasquan System and pumped to the Glendola Reservoir.

NEW JERSEY AMERICAN WATER – COASTAL NORTH SYSTEM – OAK GLENN TREATMENT PLANT

Originally constructed in 2003, New Jersey American's Oak Glenn Treatment Plant is a critical water supply asset to the region. Due to rapid population growth throughout the mid 2000's, NJAWC sought to enhance and upgrade the plant to meet increasing normal and peak demands for potable water. An expansion project at the treatment plant began in early 2016 and finished in 2019 which expanded treatment capacity from the originally designed 10 mgd to 17.5 mgd.

BRICK TOWNSHIP MUNICIPAL UTILITIES AUTHORITY

The Brick Township Municipal Utilities Authority (BTMUA) serves Brick, portions of Howell, and provides bulk sales to Point Pleasant Beach, Point Pleasant Borough, and Lakewood Township. The BTMUA has a number of groundwater wells (including those formerly owned by Parkway Water Company (PWC) due to BTMUA's acquisition of PWC), two surface water intakes on the Metedeconk River, and a reservoir. The reservoir is located on a 120-acre tract that borders Brick and Wall Townships, has a water surface area of approximately 90 acres, and holds approximately one billion gallons of water. The reservoir is operated as a pump/storage facility which is fed by a 42" ductile iron pipe which pumps water from the Metedeconk River to the reservoir and releases through the same pipe via gravity. The Metedeconk River is fed by a 70-square mile watershed that traverses seven municipalities in northern Ocean and southern Monmouth counties. The BTMUA draws water from two sources: the river, which supplies 74 percent of the water, and BTMUA's 2,000-foot-deep wells which draw water from the Raritan Magothy Aquifer. The existing allocation of the surface water system is 650 mgm and 3.7 bgy.

The safe yield of the surface water system is calculated to be 17 mgd, based on the 1981 and 2002 droughts. In addition, the creation of the BTMUA reservoir (860 million gallons) increased the storage of the Coastal North Drought Region from 7.9 bg to 8.8 bg (an 11.39% increase). This system must maintain a passing flow at the North Branch of the Metedeconk River of 14 cfs.

COASTAL SOUTH DROUGHT REGION

ATLANTIC CITY MUNICIPAL UTILITIES AUTHORITY

The Atlantic City Municipal Utility Authority (ACMUA) was established on September 14, 1978 by action of the Board of Commissioners of the City of Atlantic City, who created it under the provisions of the New Jersey Municipal and County Utilities Law. On Jan 22, 1980, the ACMUA acquired the Atlantic City Water Utility and assumed operation and maintenance of the system. ACMUA now serves approximately 150,000 people in Atlantic County. The Authority's main facilities include two surface water reservoirs**,** Kuehnle and Doughty Ponds with a combined capacity of approximately 500 million gallons. The ACMUA also possesses twelve wells and three water towers with a combined capacity of more than 9 million gallons.

SOUTHWEST DROUGHT REGION

The Southwest Drought Region runs along the western side of the state along the Delaware River from Trenton to south of Camden. The region includes two major regional surface water suppliers the City of Trenton and the New Jersey America Water Company - Western Division. Both systems have intakes on the mainstem of the Delaware River.

NEW JERSEY AMERICAN WATER COMPANY DELRAN WATER TREATMENT PLANT – DELAWARE RIVER INTAKE

The NJAWC Delran Water Treatment Plant treats water drawn from the Delaware and delivers as much as 40 mgd of water to its customers. Built in 1996, the plant was created to address the regional critical water supply needs the region's groundwater supplies could not as part of the Critical Area 2 declaration. This on river diversion is used for Public Community Supply and serves Approximately 260,000 people in the following communities: Beverly City, Burlington Township, Cinnaminson Township, Delanco Township, Delran Township, Edgewater Park Township, Maple Shade Township, Moorestown Township, Mount Laurel Township, Palmyra Borough, Riverside Township, and Riverton Borough in Burlington County; Audubon Borough, Audubon Park Borough, Barrington Borough, Bellmawr Borough, Camden

City, Cherry Hill Township, Clementon Borough, Gibbsboro Borough, Gloucester Township, Haddon Heights Borough, Haddon Township, Haddonfield Borough, Hi-Nella Borough, Laurel Springs Borough, Lawnside Borough, Lindenwold Borough, Magnolia Borough, Mount Ephraim Borough, Oaklyn Borough, Pennsauken Township, Runnemede Borough, Somerdale Borough, Stratford Borough, and Voorhees Township in Camden County; and Elk Township in Gloucester County.

TRENTON WATER WORKS – THE CITY OF TRENTON – DELAWARE RIVER INTAKE

Trenton Water Works, owned and operated by the City of Trenton, maintains the Trenton Water Filtration Plant which has the capacity to treat and distribute 65 mgd of water from the mainstem of the Delaware River to an approximate population of 200,000. The water is diverted into two 8’ x 5’ tunnels open to the river 200’ from the bank. The diverted water flows by gravity to three pumps where it is combined, metered, and treated. The systems diversion serves the communities of Trenton, Ewing, and portions of Lawrence, Hamilton, and Hopewell Townships. Trenton distribution system is currently interconnected with Aqua New Jersey, New Jersey American Water – Elizabethtown and Lawrence Township.

State of New Jersey
Department of Environmental Protection

2024 NEW JERSEY STATEWIDE WATER SUPPLY PLAN

APPENDIX C

WATER MANAGEMENT OPTIONS: CONFINED AQUIFERS OF THE NEW JERSEY COASTAL PLAIN

WATER MANAGEMENT OPTIONS: CONFINED AQUIFERS OF THE NEW JERSEY COASTAL PLAIN

Table of Contents

NEW JERSEY COASTAL PLAIN CONFINED AQUIFER SYSTEM

The confined aquifers of the New Jersey Coastal Plain are a major water supply source for New Jersey. DEP estimates that about 3.4 million people live in the Coastal Plain and rely on water provided by a public community system, while around 550,000 get their water from private, domestic wells. Confined aquifers supply 48% of the withdrawals made by those systems in the Coastal Plain, along with 27% from unconfined aquifers, and 25% from surface water. Groundwater withdrawals from the region's 10 confined aquifers totaled approximately 160 million gallons a day (mgd) in 2020. The future availability of water from the New Jersey Coastal Plain confined aquifers is constrained by several factors, including:

- Water Supply Critical Area 1 and 2 regulations and any future revisions to those regulations;
- water level instability within the aquifers;
- water level interference with other users;
- potential surface water and wetlands impacts in aquifer outcrop areas; and
- saltwater intrusion threats to seaward and bayward margins of the aquifers.

Increased use of the confined aquifers over the past few decades has resulted in a progressive decline in water levels in some areas and saltwater intrusion in other areas. Impacts from this progressive decline include the development of large cones of depression (cone-shaped water-level surfaces that point downward) centered around pumping wells, and a reversal in natural hydraulic gradients. The decreased pressure of fresh water can no longer resist the intrusion of denser salt water, which results in an induced incursion of brackish/saline waters from adjacent aquifer and surface water bodies (Gordon, Carleton, & Rosman, 2021). Sea level rise also increases the risk of saltwater intrusion, but this is a much more gradual process. Several locations have areas with compromised confined aquifers due to saltwater intrusion such as Raritan Bay, the New Jersey Pine Barrens of Gloucester County, Cape May County, and the Delaware River Valley.

Hydrogeologic analysis of the New Jersey Coastal Plain's confined aquifer systems has shown the highly interconnected nature of the individual aquifers and their connection to the water-table systems. Water withdrawn from most Coastal Plain confined aquifers comes principally from an overlying or underlying confined aquifer(s) and/or the water table system. The interconnected nature of water flow within the Coastal Plain emphasizes the need for a comprehensive examination of the Coastal Plain confined aquifer system from a regional water supply planning perspective and an assessment of potential additional sources of water supply. Existing regional water-resource examinations and analyses conducted as part of this Plan update have revealed that only limited supplies are available in confined aquifers without violating current regulatory restrictions or creating the risk of unsustainable water extraction. Several factors may influence where additional supplies may be available, such as potential water-table system impacts, tolerance for suppressed water-level elevations, and potential changes in water quality.

Based on the findings of regional studies and associated water demand projections, many of the State's confined aquifers are either approaching, have approached, or exceeded sustainable levels of use. Diminishing water levels, increased recharge from vulnerable water-table aquifers, and increased chloride and sodium concentrations have generated concern with relying on confined aquifers for future supplies. Desalination has been proposed as a helpful tool to increase future water supplies while addressing increased saltwater intrusion, and several regional studies have discussed the need for desalination as a water supply option (for more information, see Lacombe, Carleton, Pope, & Rice, 2009; Spitz, 1996). The State's first saltwater desalination well in Cape May City was installed in the late 1990's and has helped to decrease water withdrawals from the semi-confined Cohansey Aquifer.

Managed Aquifer Recharge (MAR) has also been proposed as a way to use confined aquifers as storage reservoirs to provide additional water to meet peak demands. MAR involves injecting water from other sources, such as other aquifers, treated surface water, or even treated wastewater, into aquifers to increase short-term supply availability while avoiding long-term confined aquifer impacts. Current challenges that limit MAR's viability as a water supply solution include the mechanics of well constructure, development, extraction, and the contrasting geochemistry of water sources and its effect on well screens.

The present discussion of the characteristics, status and trends, and potential availability of water from the various confined aquifers of the New Jersey Coastal Plain is organized into four regions:

1. Atlantic Coastal Region;
2. Cape May Peninsula;
3. Water Supply Critical Area 1; and
4. Water Supply Critical Area 2 and the Delaware Bay Region.

Note that while the confined aquifers were categorized based on larger pumping regions, several of them are geographically located in multiple regions (and aquifer discussion considers impacts to each impacted region).

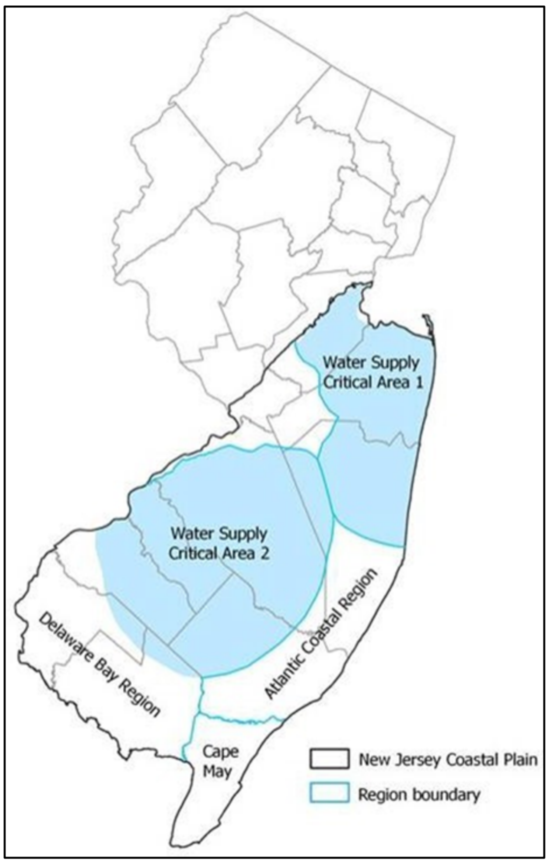

Figure C1. Water Supply Critical Areas and Major Aquifer Regions of New Jersey

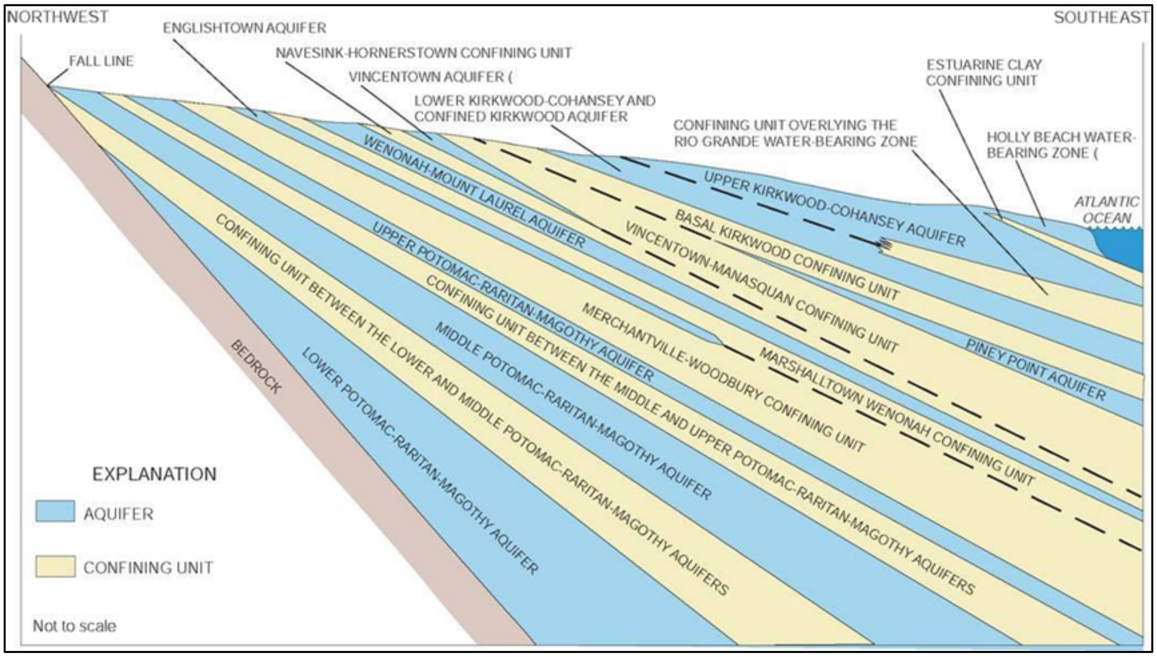

Figure C2. Generalized Cross Section of New Jersey's Coastal Plain Aquifer System (from Charles et al., 2011)

ATLANTIC COASTAL REGION – AVAILABLE WATER SUPPLY FROM CONFINED AQUIFERS

Confined aquifers are the primary water supply source along the Atlantic Coast and are heavily relied upon among communities along the barrier island complex that borders the Atlantic Ocean. The primary confined aquifer water supply source for these communities is the Atlantic City 800-foot Sand Aquifer. However, minor supply is also provided by the Piney Point Aquifer.

ATLANTIC CITY 800-FOOT SAND AQUIFER

The Atlantic City 800-foot Sand Aquifer is considered a major confined aquifer in the Kirkwood Formation. The Atlantic City 800-foot Sand Aquifer is considered the primary confined aquifer supplying water to New Jersey's barrier island communities in southern Ocean County to Cape May City, but also supplies water as far inland as Egg Harbor City (Gordon et al., 2021; DePaul & Rosman, 2015; DePaul, Rosman, & Lacombe, 2009). The aquifer's updip limit extends from southern Ocean County to eastern Cumberland County. The updip limit is based on the updip limit of the overlying confined unit, but this unit is poorly defined in places. The downdip limit is offshore of Ocean, Atlantic, and Cape May counties (Gordon et al., 2021; DePaul & Rosman, 2015). The aquifer has been found to thicken downdip and to the south, from approximately 40ft at Barnegat Light to over 200ft at Cape May City in Cape May County (Zapecza, 1989).

The Atlantic City 800-foot Sand Aquifer has been found to receive and lose water from several different sources. Major sources of water input into the aquifer include lateral flow from offshore, lateral flow from the updip, flow from the overlying aquifer, and lateral flow from the 250 mg/L isochlor line, while the major source of water loss is from withdrawals from pumping wells (USGS, forthcoming). Recharge to the aquifer can occur from vertical flow from the overlying Kirkwood-Cohansey aquifer system and Rio Grande Water-bearing Zone or by lateral flow from the Kirkwood Cohansey aquifer system (Gordon et al., 2021).

The Atlantic City 800-foot Sand Aquifer presents several significant challenges to future water supply considerations. Hydrogeologic studies have revealed that increased use will cause a continuation of ground-water level decline. As of 2013, USGS estimated the total withdrawals from the Atlantic City 800-foot Sand Aquifer were 23.8 mgd, indicating a slight decline over a 10-year period. Three major pumping centers are located along Atlantic County's barrier islands: Absecon Island, Brigantine, and Pleasantville (Gordon et al., 2021; DePaul et al., 2009). According to the most recent water-level data collected by USGS (2018 data), a large cone of depression extends beneath the coastal barrier island communities from Barnegat Light in Ocean County to Cape May City. Three small cones are also present in southern Cape May County around pumped wells for Cape May City, Wildwood City WD, Rio Grande wellfield (WCWD), and Avalon (USGS, forthcoming). All of the identified cones of depression have been identified in previous USGS studies (Gordon et al., 2021; DePaul & Rosman, 2015; DePaul et al., 2009).

USGS comparisons of aquifer well water levels between 2013 and 2018 found water levels slightly recovered in the aquifer, with water levels staying the same in Cape May City. Aquifer water level decline between 2013 and 2018 was found around several WCWD production wells. However, recovery was found in several locations including Avalon, the southern end of Long Beach Island, and low water level areas in Ventnor City, Margate City, and Longport Borough (USGS, forthcoming).

A USGS examination of different 2040 water demand scenarios for the Atlantic City 800-foot Sand Aquifer found future withdrawals could result in a mixture of decline and recovery or widespread

decline, depending on the future intensity of withdrawals. Areas projected as likely to experience water level decline in the future include areas around both Hamilton Township and New Jersey American wells (USGS, forthcoming).

Increased water use from the Atlantic City 800-foot Sand Aquifer also presents the increased risk of saltwater intrusion, especially in areas in the southwest. The Atlantic City 800-foot Sand Aquifer contains freshwater throughout southern Ocean, Atlantic, and northern Cape May counties, but has been found to become more chloride-rich south of Avalon (DePaul & Rosman, 2015). Due to the regional extent of the aquifer, significant withdrawals from the aquifer in Atlantic County may result in significant water level decline in Cape May County, and vice-versa. Many municipalities in Cape May also rely on this aquifer for water supply. Therefore, the presence of a saltwater front (250 mg/L isochlor line) approximately two miles to the south-southeast of Stone Harbor Borough is a concern being closely monitored (Gordon et al., 2021).

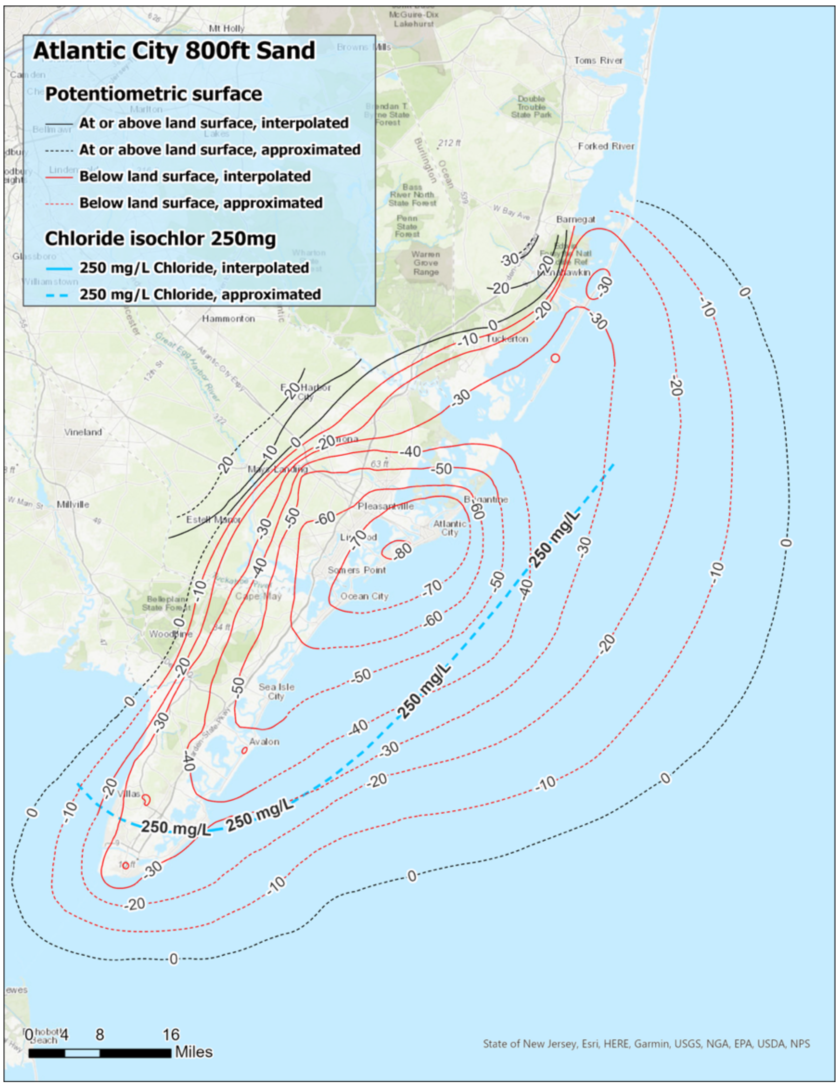

Figure C3. 250 mg/L isochlor line and potentiometric surface for Atlantic City 800-foot Sand Aquifer from the USGS report on the condition of New Jersey's confined aquifers in 2013, the most recent year for which such data is published (Gordon et al., 2021; Charles, 2016). The two aforementioned references apply to all following figures.

PINEY POINT AQUIFER

The Piney Point Aquifer is considered a minor confined aquifer in the Coastal Plain. Most groundwater withdrawals from the Piney Point Aquifer are from coastal Ocean County, Buena Borough (located in western Atlantic County), and around Bridgeton City (Cumberland County) (Gordon et al., 2021). Development of the Piney Point Aquifer in Cumberland's Bridgeton was partially in response to water quality issues in the overlying Kirkwood-Cohansey Aquifer (DePaul & Rosman, 2015; DePaul et al., 2009). The aquifer's updip limit is generally 40ft thick and is located in Ocean, Burlington, Camden, Gloucester, and Salem counties, and is near the Vincentown Aquifer's downdip limit (Gordon et al., 2021; DePaul et al., 2009). Aquifer thickness varies, with the most thickness exceeding more than 200ft in southwestern Cumberland County and over 130ft in Burlington and Ocean counties. In the southwest Coastal Plain, aquifer thickness has been found to increase southward and downdip from the northwest limit of the aquifer (Zapecza, 1989).

The Piney Point Aquifer receives and loses water from several different sources. As the aquifer has no surface expression, it relies entirely on leakage from overlying and underlying aquifers. Major sources of water flow out of the aquifer include withdrawals from pumping wells and flow to the underlying aquifer (USGS, forthcoming). There is also potential for flow from the Piney Point Aquifer to the overlying aquifers. The onshore part of the 250 mg/L isochlor line is estimated to occur from eastern Atlantic County to northern Cape May County (Gordon et al., 2021; DePaul & Rosman, 2015). This line is estimated to be more than 15 miles downdip from Buena's production center (DePaul et al., 2009).

As of 2013, Piney Point Aquifer withdrawals were approximately 5.2 mgd, which reflects a slight increase over a 10-year period. Most withdrawals from the aquifer occur in Ocean County (Gordon et al., 2021). According to the most recent water-level data collected by USGS (2018 data), several cones of depression were found, which include: (a) one underlying Seaside Park in Ocean County close to where the aquifer is most utilized in New Jersey; (b) a deep cone of depression centered in south of Bridgeton City, Cumberland County; and (c) a smaller cone of depression centered in Buena Borough (USGS, forthcoming). These cones of depression have also been found in previous USGS studies (Gordon et al., 2021; DePaul & Rosman, 2015).

USGS comparisons of aquifer well levels between 2013 and 2018 found the cones of depression in Bridgeton City and Buena Borough deepened. Sizable decline was also found in wells nearby Berkeley Township MUA. However, recovery was found in several wells in Seaside Park Borough and Seaside Heights Borough and a well located north of a center of depression centered in Barnegat Light (USGS, forthcoming).

The Piney Point Aquifer provides sufficient yield for public supply in its northeastern extent (west Atlantic, Ocean, and Burlington counties) and may continue to serve as a viable source of moderate quantities of water in its northern extent as either a replacement or alternative supply source. However, the southwest extent of the aquifer appears limited in potential for additional major water supplies due to its limited extent and rapid decline in water levels in reaction to pumping. This has been confirmed based on recent water level decline around Bridgeton City wells following the development of the aquifer in Bridgeton City in 2003 (Gordon et al., 2021). This was also found based on USGS comparisons of different 2040 water demand scenarios, which projected future water level decline in Gloucester, Cumberland, Camden, and Salem counties, and decline around Bridgeton City wells (USGS, forthcoming). In addition, the aquifer is completely confined, which suggests that water withdrawals will come at the expense of storage in overlying and underlying aquifers.

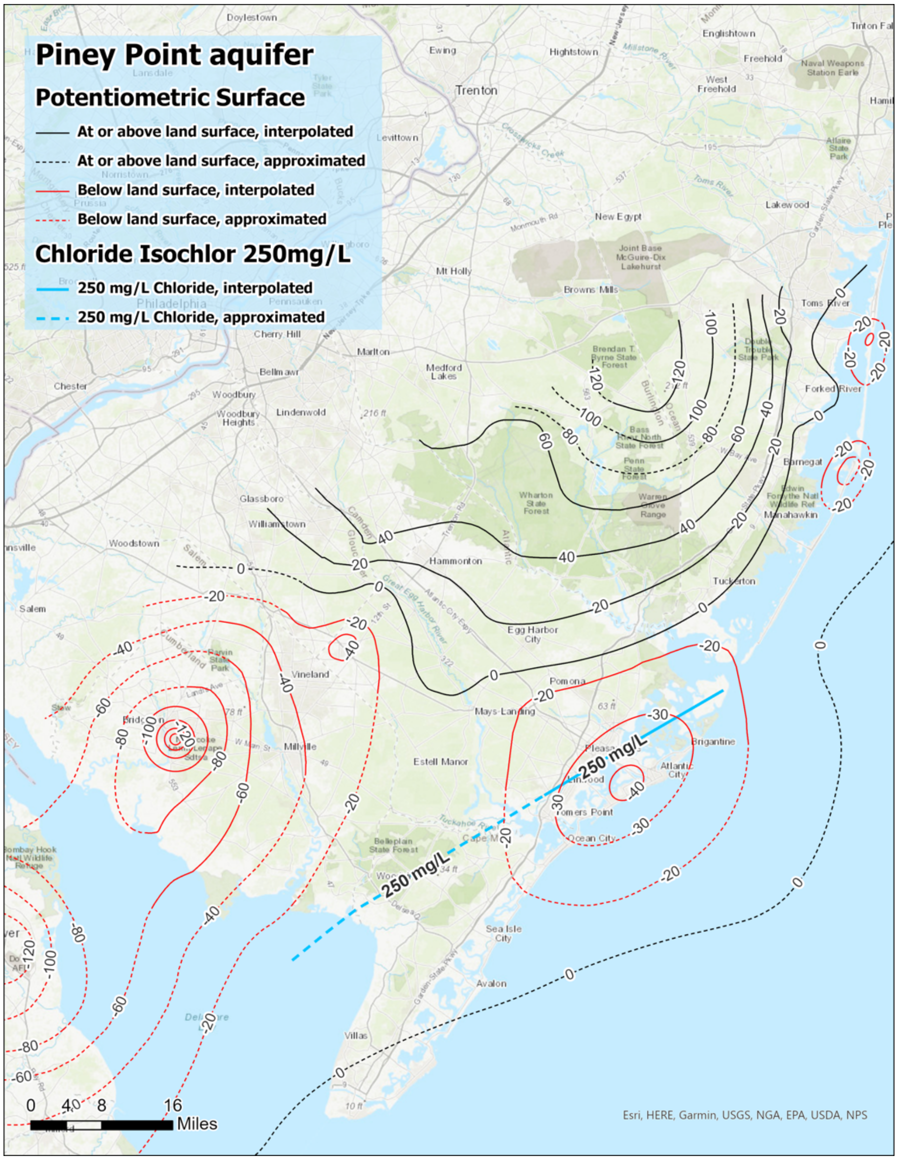

Figure C4. 250 mg/L isochlor line and potentiometric surface for Piney Point Aquifer from the USGS report on the condition of New Jersey's confined aquifers in 2013, the most recent year for which such data is published.

CAPE MAY PENINSULA – AVAILABLE WATER SUPPLY FROM ALL AQUIFERS

Cape May County is a peninsula that is surrounded by saltwater. It is likely its freshwater aquifers are exposed to saltwater under the Delaware Bay. Withdrawals from the semi-confined Cohansey Aquifer and the Atlantic City 800-foot Sand Aquifer have lowered water levels, increasing the saltwater intrusion inland. As a result, supply wells in the southern part of the peninsula, such as Wildwood, Cape May City, and Lower Township have been abandoned due to saltwater intrusion. With the establishment of a desalination plant in 1998, Cape May City Water Department has reduced its withdrawals from its confined Cohansey Aquifer wells by treating brackish water withdrawn from the Atlantic City 800-foot Sand Aquifer (DePaul & Rosman, 2015). While both the semi-confined Cohansey Aquifer and the Atlantic City 800-foot Sand Aquifer provide the majority of water supply for the Cape May Peninsula, minimal supply is also provided by the Rio Grande Water-bearing Zone in the Wildwood/Belleplain confining unit. As the Atlantic City 800-foot Sand Aquifer was previously discussed in the Atlantic Coastal Section, water supply issues surrounding both the semi-confined Cohansey Aquifer and the Rio Grande Water-bearing Zone will be discussed below.

SEMI-CONFINED COHANSEY AQUIFER

The semi-confined Cohansey Aquifer in Cape May County is considered the youngest and uppermost aquifer of the confined aquifers in the New Jersey Coastal Plain. Having a confinement limit located in northern Cape May County, groundwater is typically withdrawn in the southern peninsula in Middle and Lower townships (DePaul & Rosman, 2015; Gordon et al., 2021). The aquifer's updip limit is located in northern Cape May County and Delaware Bay, and the downdip limit is located in Cape May County east of the Atlantic Ocean shoreline (Lacombe & Rosman, 2001). While the Atlantic City 800-foot Sand Aquifer has been considered as an alternative to help meet Cape May's water supply demands, a 2007 USGS study found that increased withdrawals from the 800-foot sand aquifer would result in significant water level decline in both Cape May and Atlantic counties, regardless of where the wells were located.

Water quality data for the semi-confined Cohansey Aquifer suggests that Cape May County has exceeded sustainable withdrawal levels, highlighting the need to maintain aquifer water levels to reduce the risk of further saltwater intrusion. Although the Cohansey aquifer contains freshwater in most of mainland Cape May County, saltwater has been found in southern parts of the peninsula. Locations where saltwater has been detected include back bays and barrier islands north of Wildwood, parts of the west coast of the peninsula, and beneath near-shore and offshore areas of Delaware Bay and the Atlantic Ocean. The 250 mg/L isochlor line is estimated to be near Villas, Cape May County (Gordon et al., 2021; DePaul & Rosman, 2015).

Withdrawals from the semi-confined Cohansey Aquifer were estimated at 3.3 mgd in 2013, which declined over a 10-year period. The largest users were wells near Rio Grande, followed by wells in Lower Township (both for public supply) (Gordon et al., 2021). However, other significant sources of water withdrawal from the aquifer include Wildwood Water Utility and Lower Township Municipal Utilities Authority (MUA) (Lacombe & Rosman, 2001; Lacombe & Rosman, 1997). A comparison of aquifer well water levels between 2013 and 2018 found that aquifer water levels remained stable, with most wells having small to moderate net water level changes (5ft or less) (USGS, forthcoming). According to the most recent water-level data collected by USGS (2018 data), a long-term cone of depression is located beneath major withdrawal areas in the southern part of the peninsula, including Lower Township, Cape May City Borough, and parts of southern Middle Township (USGS, forthcoming; Gordon et al., 2021; DePaul & Rosman, 2015; DePaul et al., 2009). USGS examination of potential water supply alternatives

for the Cape May peninsula found that all alternatives resulted in additional saltwater intrusion, unless they include injection of reclaimed, treated wastewater. Generally, wells located along the 'spine' or central region of Cape May peninsula have the best long-term sustainability.

Figure C5. 250 mg/L isochlor line and potentiometric surface for the Cohansey Aquifer from the USGS report on the condition of New Jersey's confined aquifers in 2013, the most recent year for which such data is published.

RIO GRANDE WATER-BEARING ZONE

The Rio Grande Water-bearing Zone is described as a thin confined aquifer that is located midway in the confining bed overlying the Atlantic City 800-foot Sand Aquifer (Zapecza, 1989). Considered of minor importance as a potable water source in New Jersey, the aquifer is the least utilized of the 10 Coastal Plain confined aquifers, being primarily used in southern Cape May County. The aquifer is thickest in southern Cape May County (can be greater than 100ft), while it is usually less than 40ft thick in coastal southern Ocean and Atlantic counties (Gordon et al., 2021; DePaul & Rosman, 2015; Zapecza, 1989). The

updip extent of the aquifer approximately coincides with the extent of the Atlantic City 800-foot Sand Aquifer, extending from southern Ocean County through eastern Cumberland County (Gordon et al., 2021; DePaul & Rosman, 2015). Water levels in the Rio Grande Water-bearing Zone have also been found to coincide with water levels in the underlying Atlantic City 800-foot Sand Aquifer (Lacombe & Rosman, 2001).

The aquifer's fresh groundwater is located under mainland coastal regions and barrier islands spanning from southern Ocean County to most of mainland Cape May County. However, interaction with saltwater is likely, as saline water is located in southern Cape May County and likely under near shore areas, barrier islands, and back bays from Avalon to Cape May City. As of 2015, the 10,000 mg/L isochlor line was not determined for this aquifer, but may be located near the isochlor line for the Atlantic City 800-foot Sand Aquifer (DePaul & Rosman, 2015; DePaul et al., 2009).

While suitable for meeting limited localized water demands in Cape May County, the Rio Grande Water-bearing Zone is not considered a viable water supply alternative due to its limitations in thickness and its high transmissivity with the underlying Atlantic City 800-foot Sand Aquifer. As of 2013, the Rio Grande Water-bearing Zone withdrawals were approximately 0.5 mgd, which is a slight decline over a 10-year period. The most significant withdrawals were by purveyors in Long Beach and Little Egg Harbor Township (southern Ocean County), and in Middle Township (Cape May County) (Gordon et al., 2021). According to the most recent water-level data collected by USGS (2018 data), a cone of depression is centered beneath coastal New Jersey and extends from the Cape May peninsula northward past Ship Bottom in southern Ocean County. This cone is consistent with the water level decline found in a cone of depression in the underlying Atlantic City 800-foot Sand Aquifer. A newly developed cone of depression was also found in the center of the Cape May peninsula around Wildwood City Water Department (WCWD) Rio Grande wellfield in southern Middle Township. Well water levels located around the WCWD were found to decline between 2013-2018. However, slight recovery was found among wells located in northern Cape May, Atlantic, and Ocean counties. USGS examination of different 2040 water demand scenarios projected some water level decline for most areas of the water-bearing zone, especially around Little Egg Harbor Township wells (USGS, forthcoming).

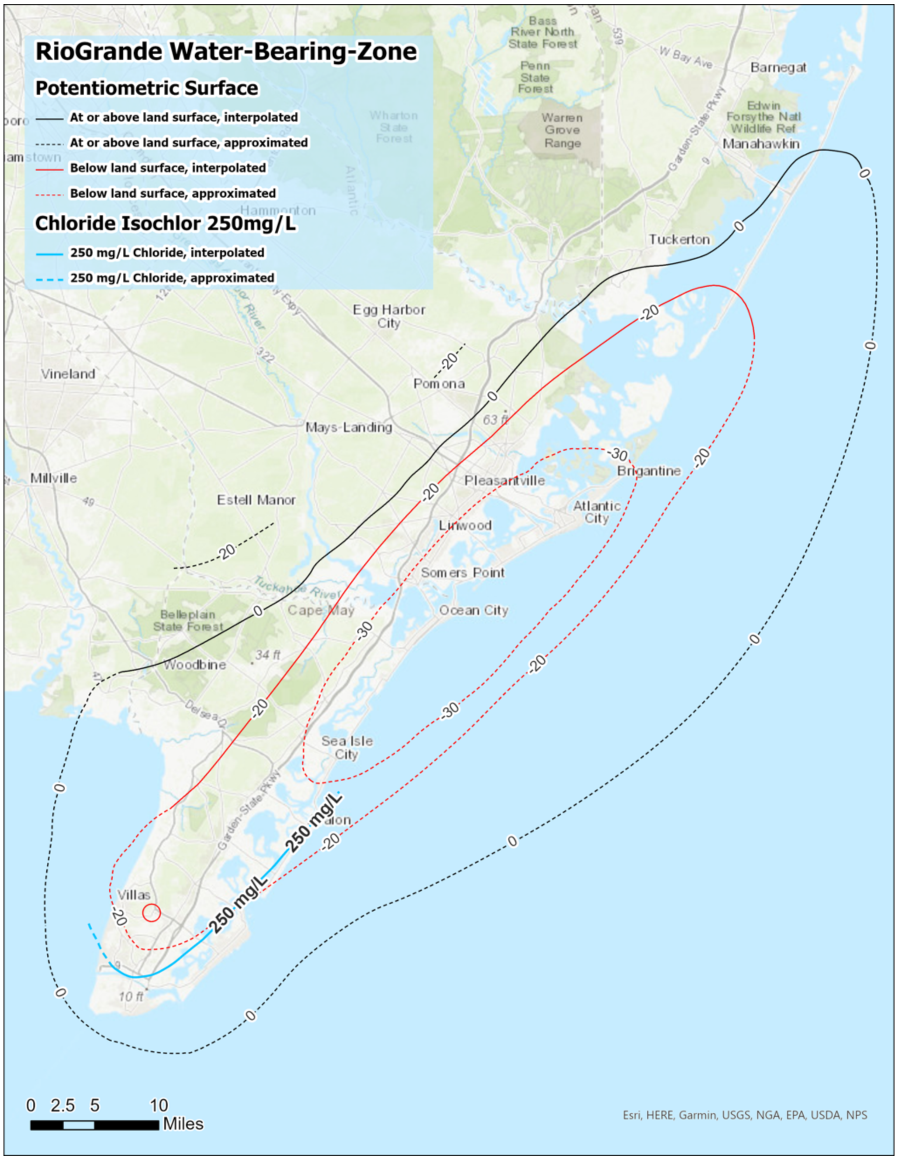

Figure C6. 250 mg/L isochlor line and potentiometric surface for Rio Grande Water-bearing Zone from the USGS report on the condition of New Jersey's confined aquifers in 2013, the most recent year for which such data is published.

WATER SUPPLY CRITICAL AREA 1 – AVAILABLE WATER SUPPLY FROM CONFINED AQUIFERS

The State declared two areas of “critical waters supply concern” in the New Jersey Coastal Plain during the 1980’s and 1990’s in response to regional progressive water-level declines and saltwater intrusion within the confined aquifers. Designated as Water Supply Critical Areas 1 and 2, reductions in use and imposed restrictions on future use were mandated by the State and surface water options were offered as alternatives to replace ground-water supply. Critical Area 1 was established in 1989, but due to lack of access to alternative water supplies, compliance by most purveyors was delayed until 1991 (Gordon et al., 2021). Water Supply Critical Area regulations allow for the assessment of progress for each Critical Area’s management plan and the opportunity for the plan to be restructured after 10 years.

Re-examination of Critical Area 1 began in 2001 which involved USGS modeling efforts, evaluation of ground-water level trends, and an assessment of the availability of water supply alternatives. Based on the findings, it was concluded that a small amount of additional groundwater may be available from Critical Area 1’s confined aquifers at optimal locations, the water-supply alternatives identified in the 1996 New Jersey Statewide Water Supply Plan would continue to be endorsed, and additional water may be available to meet seasonal needs through use of MAR and redistribution of annual pumping schemes (Spitz, Watt, & DePaul, 2008). Examples of efforts to decrease confined aquifer withdrawals in Critical Area 1 include increased use of surface-water withdrawals (from sources such as the Manasquan Reservoir, which began operation in 1990), and withdrawals from shallower, unconfined aquifers (Gordon et al., 2021; DePaul et al., 2009).

The area between the boundaries of Water Supply Critical Areas 1 and 2 (includes Mercer, north Burlington, southwest Middlesex, and west Monmouth counties), may also be subject to confined aquifer withdrawal constraints. Since this area is located near the outcrop area for several confined aquifers, the level of concern over withdrawal impacts is higher since the interaction between surface water and water-table aquifers may be more direct. Constraints are determined based on if the drawdown impacts from these locations extend into the Critical Area and if the withdrawals impact surface water sources, other users, and known contaminated sites.

The aquifers regulated in Critical Area 1 include: Wenonah-Mount Laurel Aquifer, Englishtown Aquifer System, and the Upper and Middle and Undifferentiated PRM Aquifers (Gordon et al., 2021). The primary confined aquifers in Critical Area 1 used for water supply include the Middle and Undifferentiated Potomac-Raritan-Magothy (PRM) Aquifer, the Englishtown Aquifer, the Wenonah-Mount Laurel Aquifer (see Critical Area 2), and the Vincentown Aquifer, which will be discussed below.

MIDDLE AND UNDIFFERENTIATED PRM AQUIFER

The Middle and Undifferentiated PRM Aquifer extends from the Raritan Bay to Maryland in the southwest. Locally referred to as the Farrington Aquifer, the aquifer is considered well defined from its outcrop area to approximately 20 miles downdip. Beyond this distance, the aquifer cannot be distinguished from underlying sediments. In southern New Jersey, the aquifer can be traced from the outcrop subsurface to approximately 10-12 miles downdip, where it becomes indistinguishable from the Lower PRM Aquifer. In locations where the confining unit is absent, the Middle PRM overlies bedrock or weathered bedrock (Gordon et al., 2021; DePaul & Rosman, 2015; Zapecza, 1989). Although the majority of withdrawals occur in Burlington, Middlesex, Mercer, and Ocean counties, the aquifer’s thickness has been found to vary between less than 50ft near its outcrop to over 150ft near the junction of Middlesex, Mercer, and Monmouth counties (Gordon et al., 2021; Rosman, Lacombe, & Storck, 1995; Zapecza,

1989). USGS has found the overall water levels within the Middle PRM Aquifer to be either stable or increasing in the cones of depression located in Critical Areas 1 and 2 (Gordon et al., 2021; DePaul & Rosman, 2015).

As of 2013, total groundwater withdrawals from the aquifer were estimated at 58.7 mgd, which has declined over a 10-year period. Primary pumping centers in the northern end of the aquifer include southern Mercer, western Middlesex, eastern Monmouth, and northern Ocean counties. In the South, primary pumping centers are located in north Burlington, Camden, and Gloucester counties, and portions of Salem County (Gordon et al., 2021; DePaul & Rosman, 2015). According to the most recent water-level data collected by USGS (2018 data), a long-term regional cone of depression is located in the center of Critical Area 2 along with a second cone of depression that includes Critical Area 1 (most of southeast Monmouth and north Ocean counties). Within the cone of depression in Critical Area 2, two smaller cones are starting to develop in Westhampton Township and New Hanover Township. Between 2013 and 2018, the center of the cone of depression in Critical Area 2 was found to deepen and migrate north from Gibbsboro to Cherry Hill, while the center of the regional cone of depression in Critical Area 1 was found to deepen and migrate from Lakewood to Brick Township (USGS, forthcoming).

The potential for additional water supply from this aquifer is very limited and localized without risking a reversal of the water level recovery that has occurred due to Water Supply Critical Area 1 regulations. USGS comparisons of different 2040 water demand scenarios found that several locations are projected to experience water level decline including areas around Jackson Township MUA wells, Salem and Hope Creek Generation Station in Lower Alloways Creek Township, NJAW Pennsgrove and Chambers Works wells in Carney's Point and Pennsville townships, and Aqua New Jersey Central Hamilton Township (Mercer County) (USGS, forthcoming).

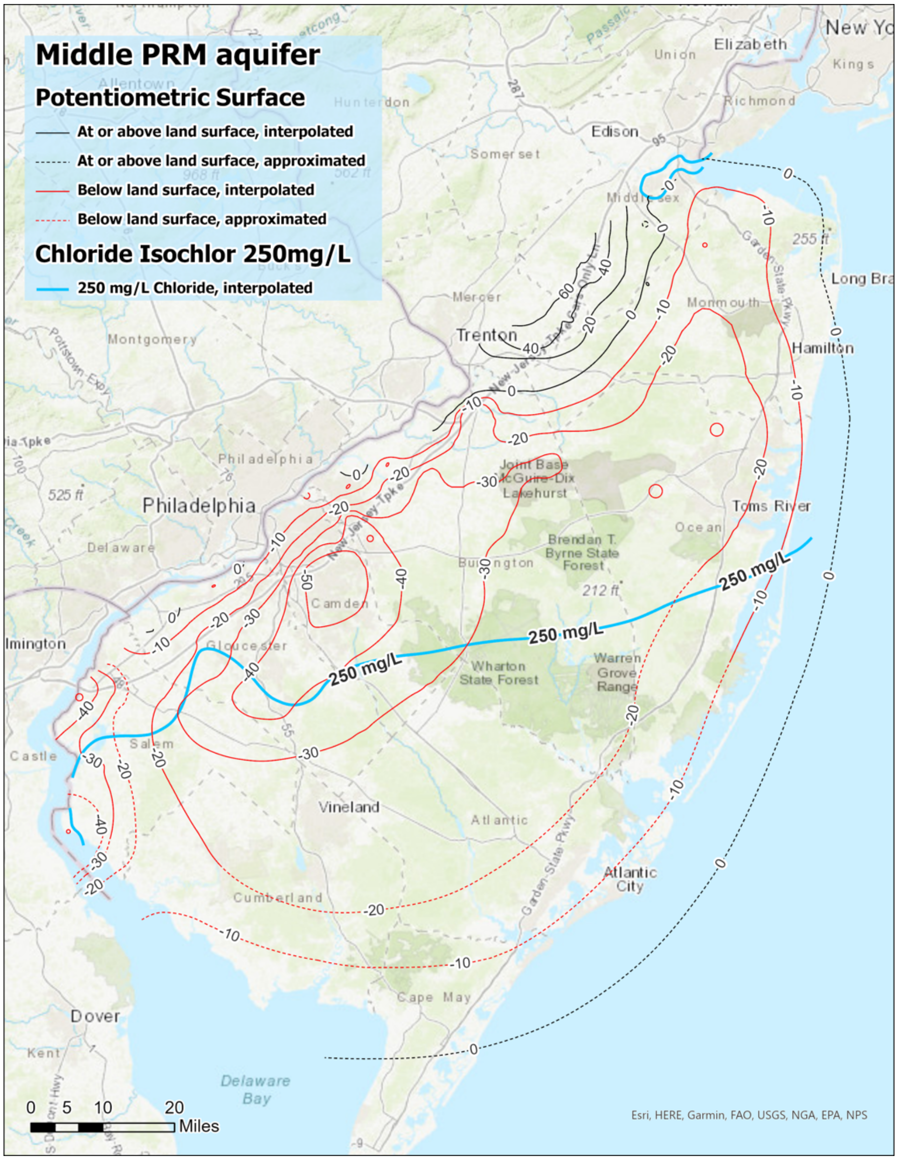

Figure C7. 250 mg/L isochlor line and potentiometric surface for Middle PRM Aquifer from the USGS report on the condition of New Jersey's confined aquifers in 2013, the most recent year for which such data is published.

ENGLISHTOWN AQUIFER SYSTEM

The Englishtown Aquifer System is capable of providing significant water supply in the northeast Coastal Plain, but is less productive in the Delaware Bay Region and Critical Area 2 due to its naturally occurring limits. The aquifer yields a large amount of water for both Monmouth and Ocean counties, which are located where the formation is sandy and thick (Gordon et al., 2021; DePaul & Rosman, 2015). The aquifer system thins in outcrop and in the subsurface in a southwest direction, in which the aquifer is commonly less than 40ft thick in parts of Burlington, Camden, Gloucester, and Salem counties (Zapecza, 1989). In Ocean County, the distance between the outcrop and downdip boundary is approximately 34 miles, but in southern Salem County, the lateral extent of the confined aquifer is approximately 12 miles (Gordon et al., 2021; DePaul & Rosman, 2015; DePaul et al., 2009). The Merchantville-Woodbury

confining unit is located under the Englishtown Aquifer, which is considered the most extensive confining unit in New Jersey's Coastal Plain (DePaul & Rosman, 2015).

In 2013, total withdrawals from the Englishtown Aquifer System were estimated at 7.9 mgd, which is a slight decline over a 10-year period. Most withdrawals from the aquifer were made in Monmouth, central Camden, north Ocean, and north-central Burlington counties (Gordon et al., 2021). According to the most recent water-level data collected by USGS (2018 data), a large cone of depression is located in southeast Monmouth County and northwest Ocean County (which approximately follows the extent of Critical Area 1 for the Englishtown Aquifer) and a smaller cone of depression is located within the larger cone in Lakewood Township, Ocean County (USGS, forthcoming). Both cones of depression have been documented in previous USGS studies (Gordon et al., 2021; DePaul & Rosman, 2015; DePaul et al., 2009; Lacombe & Rosman, 2001). The larger cone is considered similar to the cone of the overlying Wenonah-Mount Laurel Aquifer, which showed some water level decline in this area between 2008 and 2013. This suggests a good hydraulic connection between the two aquifers via vertical leakance through the Marshalltown-Wenonah confining unit (Gordon et al., 2021).

USGS comparisons of aquifer well water levels between 2013 and 2018 found overall recovery of the aquifer throughout the State, but the most significant recovery in Critical Area 1. This recovery may potentially be due to the downward flow from the overlying Wenonah-Mount Laurel Aquifer. Some decline was found in Laurel Spring Borough (Camden County), but recovery was found in many areas including Upper Freehold Township (Monmouth County), Point Pleasant Borough (Ocean County), and wells located south from Burlington County to Camden, Gloucester, and Salem counties. However, USGS examination of different 2040 water demand scenarios found several locations where water level decline was projected, including around NJAW wells in Lakewood Township and Bay Head Borough, and around Freehold WD and Greenbriar at Marlboro wells (USGS, forthcoming).

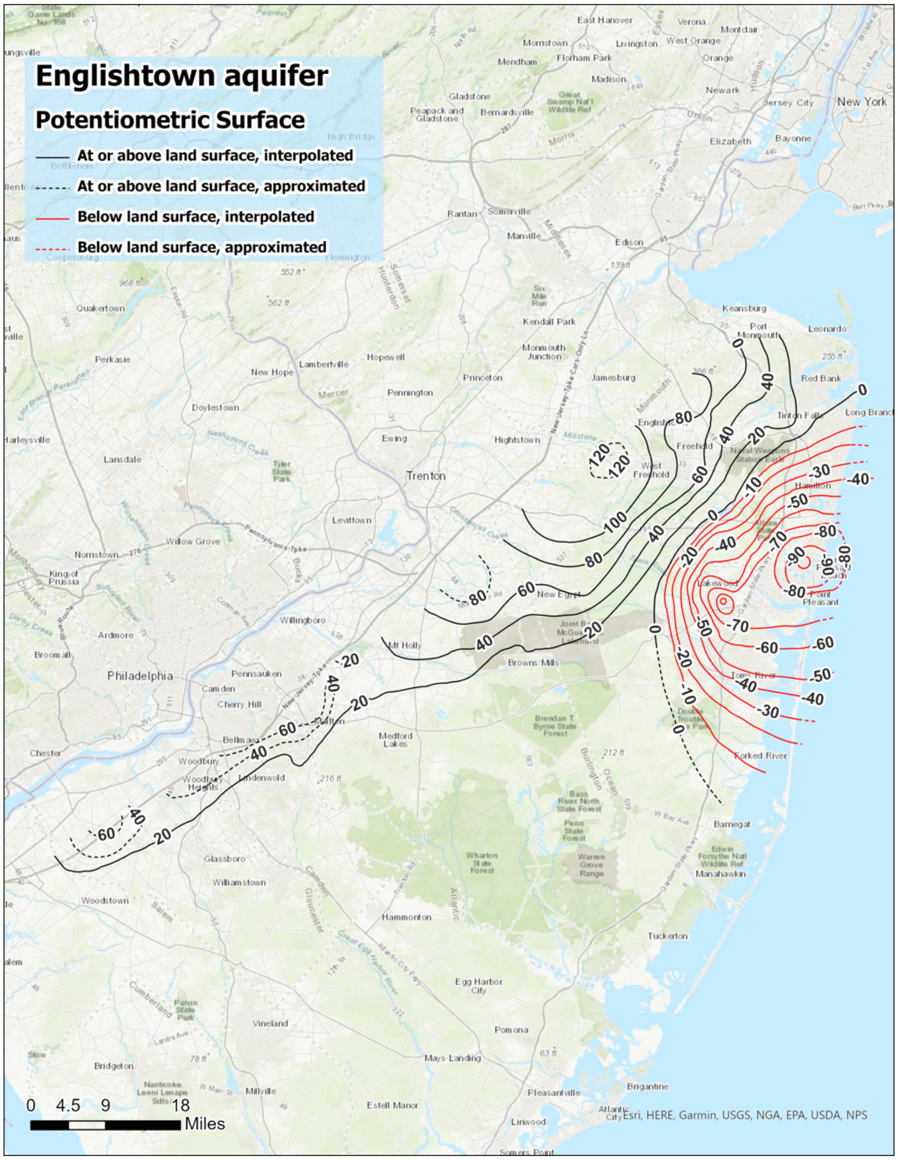

Figure C8. Potentiometric surface for Englishtown Aquifer from the USGS report on the condition of New Jersey's confined aquifers in 2013, the most recent year for which such data is published.

VINCENTOWN AQUIFER

The Vincentown Aquifer is not considered a significant source of water in southwest or south-central New Jersey due to its geographic extent and instantaneous yield. The aquifer beyond Monmouth and Ocean counties is silty and can only locally produce appreciable quantities of water (Gordon et al., 2021). The aquifer's extent can be traced in the sub-surface from Monmouth to Salem counties, in a narrow band three to 10 miles wide next to and parallel to the outcrop area (Zapecza, 1989). The outcrop area extends from northeastern Monmouth County to the Delaware River (adjacent to Salem County) (Rosman et al., 1995; Zapecza, 1989). The aquifer's down-dip area acts as a confining unit and its downdip limit has been estimated to be approximately six to eight miles southeast of the outcrop area (Lacombe & Rosman, 2001).

The Vincentown Aquifer is able to meet relatively small public supply demands due to limitations in aquifer thickness. The aquifer is considered well defined and thickest in northern Ocean and southern Monmouth counties, where it is used for water supply. It is considered less defined in the rest of the Coastal Plain (Gordon et al., 2021; DePaul & Rosman, 2015).

USGS estimated aquifer groundwater withdrawals in 2013 were approximately 1.6 mgd, which is a slight increase over a 10-year period (Gordon et al., 2021). According to the most recent water-level data collected by USGS (2018 data), there was slight water level recovery in the aquifer, especially in locations where it is most used. Recovery was found in northeast Burlington County and throughout Ocean and Monmouth counties where the aquifer is used for public supply. Recovery was also found in areas of northwest Ocean County and in coastal Salem County. Slight decline was found in Mantua Township MUA (Gloucester County) (USGS, forthcoming).

The Vincentown Aquifer is a minor option for meeting future water supply demand due to the listed limitations. USGS comparisons of different 2040 water demand scenarios found the potential for future water level decline in north Ocean County, Howell Township, and around Jackson Township MUA wells (USGS, forthcoming). Estimates of the overall supply from this aquifer are difficult to determine since the aquifer's water bearing sands are only within approximately 10 miles of its outcrop area. For this reason, withdrawals may impact streamflow, especially in areas close to the unconfined areas of the aquifer.

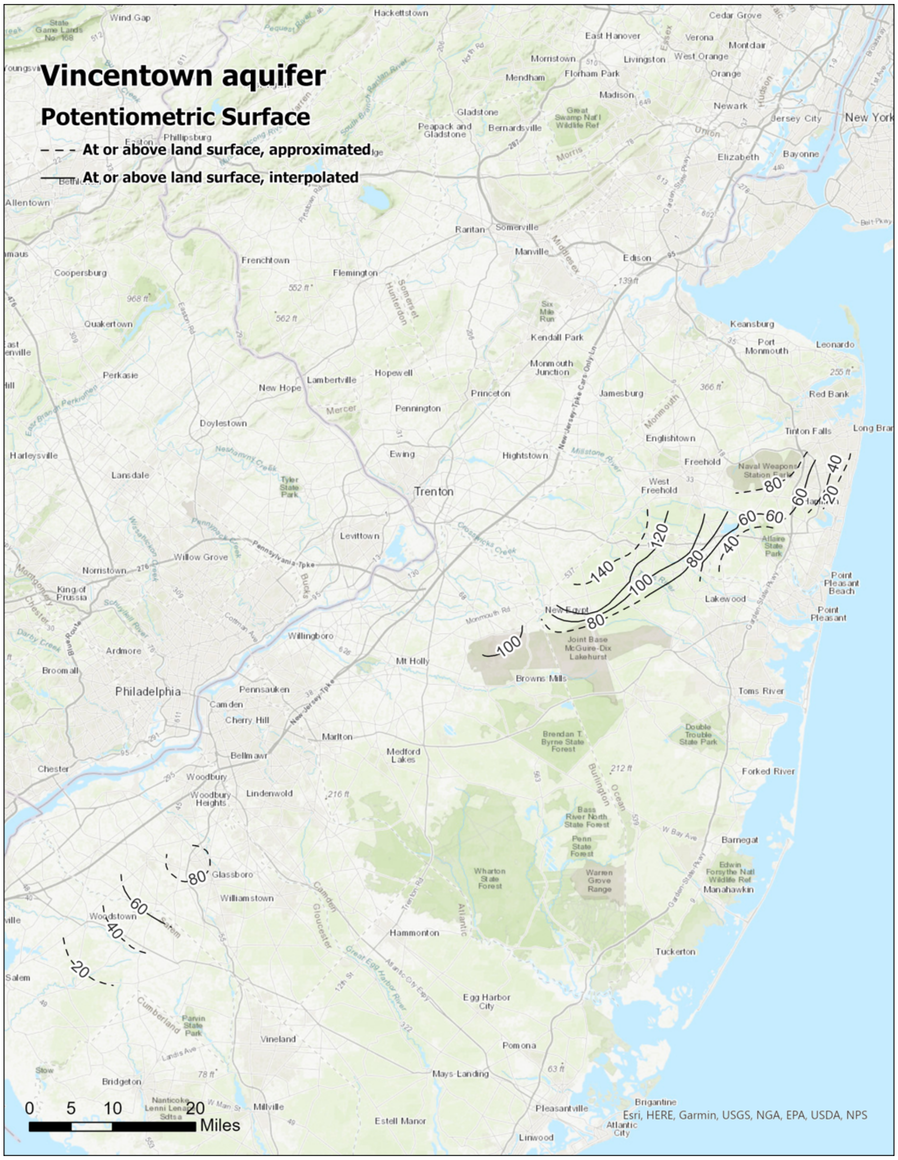

Figure C9. Potentiometric surface for Vincentown Aquifer from the USGS report on the condition of New Jersey's confined aquifers in 2013, the most recent year for which such data is published.

WATER SUPPLY CRITICAL AREA 2 & DELAWARE BAY REGION – AVAILABLE WATER SUPPLY FROM CONFINED AQUIFERS

Water Supply Critical Area 2 was established in 1993 to improve the management of groundwater resources from the PRM aquifer system in southwest New Jersey. It includes Camden, most of Burlington and Gloucester, and parts of Atlantic, Cumberland, Ocean, Monmouth, and Salem counties. The goal of this designation was to stabilize aquifer water levels by reducing pumping from the PRM aquifer system and prohibit future annual increase in PRM use since this aquifer system is the most prolific water source in the region. Unlike Water Supply Critical Area 1, which provides withdrawal restrictions for the Upper and Middle PRM aquifers, Water Supply Critical Area 2 provides restrictions for both of these aquifers along with the third and final aquifer in the PRM system: the Lower PRM Aquifer. Although not specifically included in the Water Supply Critical Area 2 designation, the decline in water-levels in the Wenonah-Mount Laurel Aquifer, which has been considered an alternative to the PRM aquifer system, was also a cause for concern (Gordon et al., 2021; DePaul et al., 2009).

Since the Critical Area 2 designation, water levels within the PRM aquifer system have recovered in several locations, and ground-water model simulations have suggested that stream flow recovery may also occur due to a decrease in pumping induced stream leakage to the aquifers in their outcrop areas. Re-examination of Critical Area 2 included an evaluation of ground-water level trends, USGS modeling, and an assessment of potential impacts of increased withdrawals. Based on the findings, it was concluded that while water level recovery was seen in the Upper, Middle, and Lower PRM aquifers, any withdrawal increases from 2003 values would cause aquifer water level declines below the minimum values mandated by DEP (Spitz & DePaul, 2008). The Tri-County Pipeline, an intake and treatment plant on the Delaware River at Delran, has served as an alternative water source to meet regional demand. This pipeline can provide over 30 mgd of Delaware River water for users in Gloucester, Camden, and Burlington counties (Gordon et al., 2021; DePaul et al., 2009).

Confined aquifers within the Water Supply Critical Area 2 region include the three aquifers of the PRM aquifer system (Upper, Middle and Undifferentiated, and Lower), the Wenonah-Mount Laurel (WML) Aquifer, and the Englishtown Aquifer. Since both the Middle and Undifferentiated PRM Aquifer and the Englishtown Aquifer were already discussed in the Water Supply Critical Area 1 section, water supply issues for the Upper PRM, Lower PRM, and WML Aquifer are discussed below.

UPPER PRM AQUIFER

The Upper PRM Aquifer is considered the most extensive unit in the PRM aquifer system. Locally referred to as the Old Bridge Aquifer, the aquifer's outcrop area mostly coincides with the outcrop of the Magothy Formation, extending from the Raritan Bay to the Delaware River in Salem County. A significant water source across the New Jersey Coastal Plain, the aquifer's downdip is considered well defined offshore of Monmouth and Ocean counties, but is considered less defined in Atlantic, Cumberland, and Cape May counties (Gordon et al., 2021; DePaul & Rosman, 2015). Aquifer thickness varies with estimated ranges from over 200ft in east Monmouth County to approximately 50ft in Cape May County (DePaul & Rosman, 2015; Zapecza, 1989). The majority of aquifer withdrawals occur in Middlesex, Camden, and Gloucester counties, but some withdrawals in Burlington County south to Salem County occur on a narrow band from the aquifer's outcrop to approximately 12 miles downdip (Gordon et al., 2021; DePaul & Rosman, 2015).

Future water-supply withdrawals from the Upper PRM Aquifer in the southwest part of Critical Area 2 and the Delaware Bay Region are constrained by the presence of the saltwater front (250 mg/L isochlor

line), which bulges close to the Delaware River in Gloucester County. In the Upper PRM Aquifer, freshwater has been found to be present throughout most of the aquifer's updip extent, but saline groundwater is present in Salem County, most of Atlantic, and all of Cumberland and Cape May counties. A regional cone of depression in Camden County has led groundwater to flow to the northeast, resulting in areas of northwest Gloucester County to be in imminent risk of saltwater intrusion. In the aquifer, the lowest chloride concentrations are located mid-dip and downdip in Monmouth, Middlesex, north Ocean, Burlington, and Camden counties, where concentrations were estimated at less than 10 mg/L. Higher concentrations (2-92 mg/L) are found in updip locations, which is likely due to anthropogenic sources (such as agricultural runoff and road deicers in local recharge areas). The aquifer's highest chloride concentrations have been found in downdip areas under Salem and Gloucester counties and limited areas in north Monmouth County (Gordon et al., 2021; DePaul & Rosman, 2015).

A continuation of aquifer water level recovery is critical to counter the threat of further saltwater intrusion. As of 2013, USGS estimated groundwater withdrawals from the Upper PRM Aquifer to be approximately 49.0 mgd, which is a decline over a 10-year period. The aquifer's primary pumping centers are located in east Middlesex County near the Magothy Formation's outcrop, and in central Camden and Gloucester counties (Gordon et al., 2021; DePaul & Rosman, 2015). According to the most recent water-level data collected by USGS (2018 data), two cones of depression are located in and around Critical Areas 1 and 2, and a third cone is located in Critical Area 2 that expands from the center of Camden County towards the Delaware River to the west, Burlington County to the northeast, and Gloucester County to the south-southwest. USGS comparisons of 2013 and 2018 aquifer well water levels found water levels declined slightly in Critical Area 1 and surrounding areas of Monmouth, Ocean, and Middlesex counties, and slightly recovered in Critical Area 2 and surrounding areas of Camden, Burlington, and Gloucester counties. However, USGS examination of 2040 water demand scenarios identified several areas where aquifer water levels are projected to decline, including north Ocean County, parts of Burlington County, and the area around Suez Toms River, Aqua Woolwich, and New Jersey Sod Realty (USGS, forthcoming).

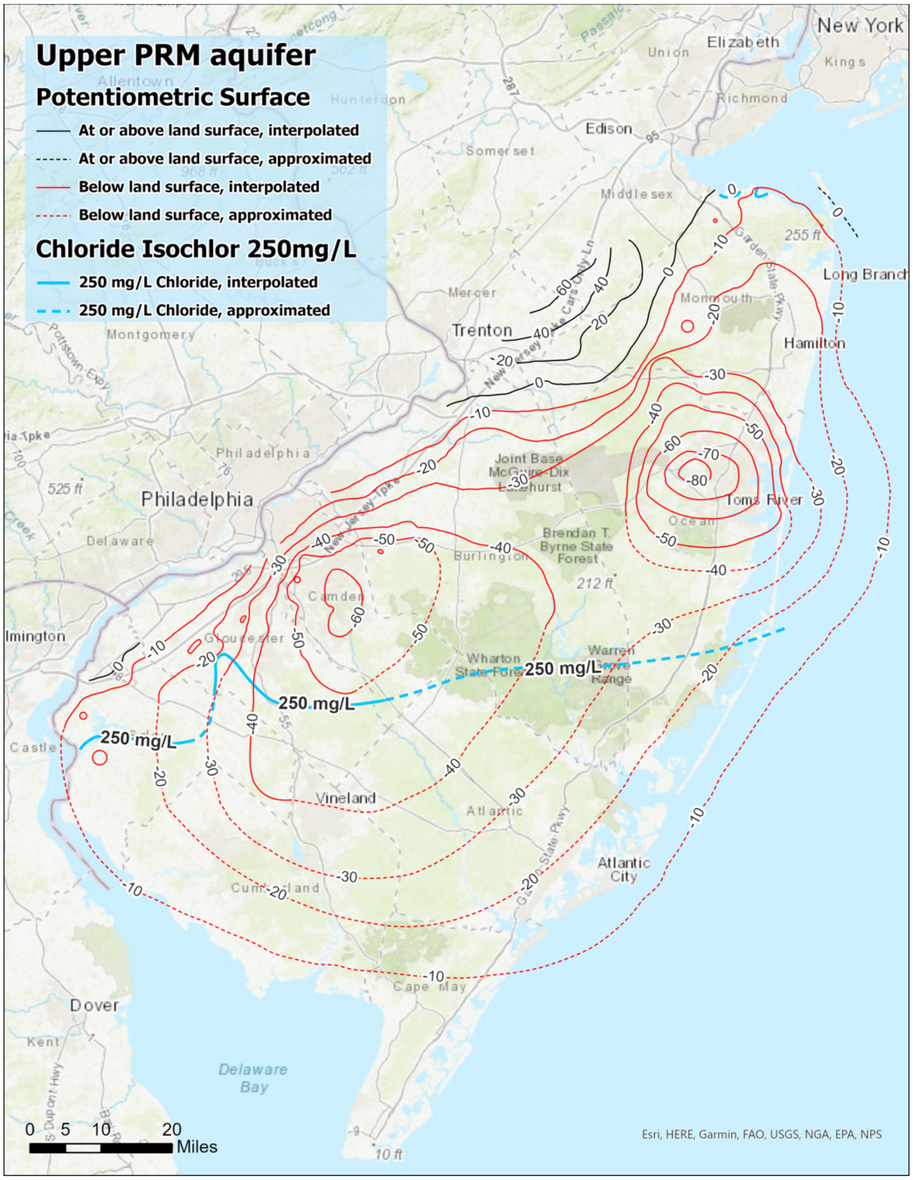

Figure C10. 250 mg/L isochlor line and potentiometric surface for Upper PRM Aquifer from the USGS report on the condition of New Jersey's confined aquifers in 2013, the most recent year for which such data is published.

LOWER PRM AQUIFER

The Lower PRM Aquifer is considered the lowermost aquifer in the New Jersey Coastal Plain. It does not crop out in New Jersey since it is entirely overlain by a confining bed that separates the Middle and Lower PRM aquifers (Gordon et al., 2021; DePaul & Rosman, 2015). Considered to have the most limited extent of the three PRM aquifers, the aquifer is considered recognizable approximately eight to 12 miles downdip from the northwest extent of the undifferentiated outcrop of the Potomac Group and Raritan Formation (Zapecza, 1989). Significant water withdrawals from the aquifer occur in north Camden County, Burlington County, and in locations near the Delaware River (Gordon et al., 2021).

Similar to the Upper PRM, the potential for future water supply withdrawals from the Lower PRM Aquifer is limited due to its risk of saltwater intrusion. The approximate location of the 10,000 mg/L

isochlor line was simulated two miles in the downdip direction from the 250 mg/L isochlor line (located in Gloucester) and three miles down in southern Salem County. Within the aquifer, chloride concentrations have been found to range from less than 2 mg/L to over 11,000 mg/L. The lowest concentrations (no more than 20 mg/L) were located in inland, downdip areas of Burlington and Camden counties. The highest concentrations (range of 143 to 850 mg/L) are found under western Gloucester County, northwest Salem County, and areas to the south and east (DePaul & Rosman, 2015).

Continuing water level recovery of the aquifer is critical for preventing future saltwater intrusion. As of 2013, total groundwater withdrawals from the aquifer were estimated at 32.9 mgd, which decreased over a 10-year period. Significant sources of withdrawal from the aquifer include Camden City Water Department, Merchantville-Pennsauken Water Commission, and New Jersey American Water (Gordon et al., 2021; DePaul & Rosman, 2015). According to the most recent water-level data collected by USGS (2018 data), there is a cone of depression in the aquifer similar to that of the overlying Middle and Undifferentiated PRM Aquifer. A comparison of aquifer well water levels between 2013 and 2018 found that water levels generally recovered in the Lower PRM Aquifer, although some decline was found in localized areas of Camden City, Mount Laurel Township, and west Alloways Creek Township. USGS comparisons of 2040 water demand scenarios identified several locations that may experience future aquifer water level decline, including NJAW Pennsgrove in Carney's Point, Pennsville WD wells, and Solvay Specialty Polymers wells (West Deptford Township) (USGS, forthcoming).

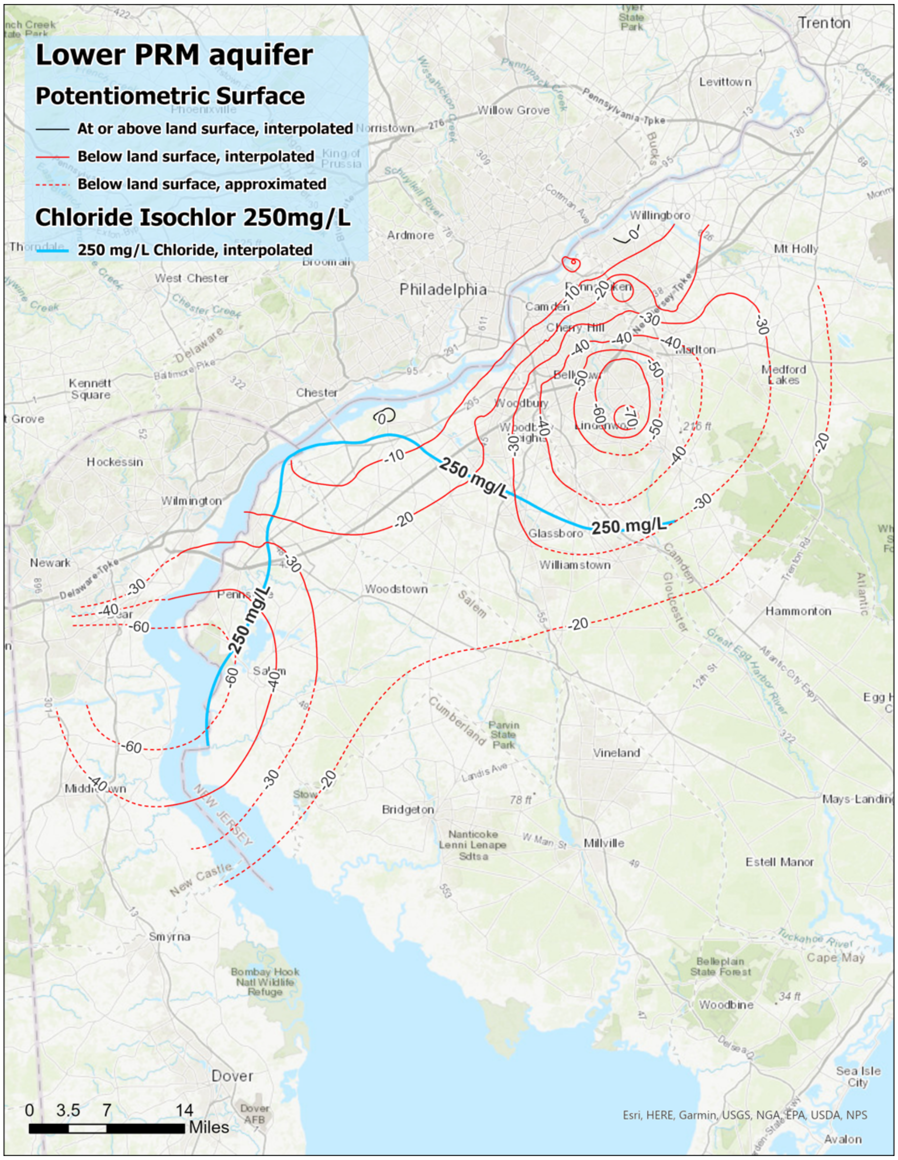

Figure C11. 250 mg/L isochlor line and potentiometric surface for Lower PRM Aquifer from the USGS report on the condition of New Jersey's confined aquifers in 2013, the most recent year for which such data is published.

WENONAH-MOUNT LAUREL (WML) AQUIFER

There has been increased interest in using the WML Aquifer as an alternative water source in Water Supply Critical Area 2 due to the limitations placed on the PRM aquifer system. Having significant withdrawals in Burlington, Camden, and Salem counties, the aquifer's outcrop area extends from Monmouth and Middlesex counties to Salem County in the southwest. The downdip limit of the aquifer is offshore along Monmouth and Ocean counties, and is considered poorly defined in Atlantic, Cumberland, and Cape May counties (Gordon et al., 2021; DePaul & Rosman, 2015). The aquifer is considered thickest in western Salem County and central Gloucester and Camden counties, where it is used for public supply. Southwest in Salem County, the productive sands decrease due to increased silt content (Gordon et al., 2021; DePaul & Rosman, 2015; DePaul et al., 2009). The 250 mg/L isochlor line is estimated to be approximately 2 miles inland in southwest Salem County (Gordon et al., 2021).

The WML Aquifer faces limitations to increased use including excessive drawdown, the potential for well interference, and wetlands and stream depletion in up-dip outcrop areas. As of 2013, estimated aquifer withdrawals were approximately 6.6 mgd, which has declined over a 10-year period. Major withdrawal centers for the aquifer include central Burlington, Camden, and Gloucester counties and Salem County (Gordon et al., 2021; Lacombe & Rosman, 2001). According to the most recent water-level data collected by USGS (2018 data), several cones of depression are located in: (a) western Burlington, southern Camden, and southeastern Gloucester counties; (b) southeastern Monmouth and northeastern Ocean Counties; (c) Medford Township, Burlington County; and (d) Pemberton Township, northeast Burlington County. The cone of depression in Camden and Gloucester counties was found to change significantly since 2013 and both expanded and deepened around the center. Parts of the cone of depression in Monmouth and Ocean counties were also found to deepen since 2013. However, the cones of depression in Medford Township and Pemberton Township were both found to recover (USGS, forthcoming).

USGS comparisons of aquifer well water levels in 2013 and 2018 found mixed water level trends. Significant declines were found in the largest cones of depression located in eastern Monmouth and northeastern Ocean Counties in Critical Area 1 and in the cone's center of Camden and Gloucester counties located in Critical Area 2. However, there were some substantial water level recoveries for the smaller cone of depression in Burlington County. USGS comparisons of different 2040 water demand scenarios identified several spots projected to experience a decline in aquifer water levels, including areas around Clayton Borough, Glassboro Borough, and Washington Township wells. The center of the cone of depression in Critical Area 1 was projected to recover in more conservative future water demand scenarios, but decline with more excessive water use (USGS, forthcoming).

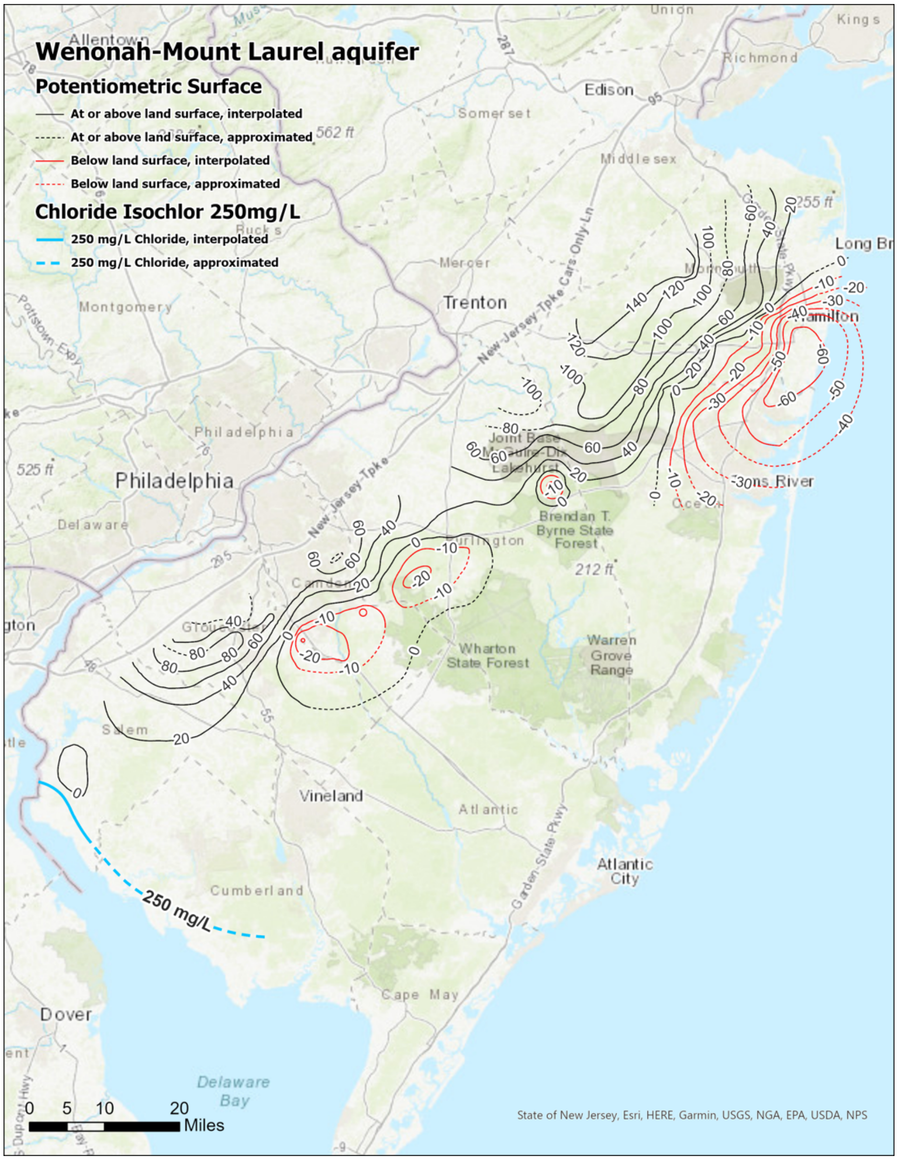

Figure C12. Potentiometric surface for Wenonah-Mount Laurel Aquifer from the USGS report on the condition of New Jersey's confined aquifers in 2013, the most recent year for which such data is published.

State of New Jersey
Department of Environmental Protection

2024 NEW JERSEY STATEWIDE WATER SUPPLY PLAN

APPENDIX D

2050 FORECAST WATER DEMANDS FOR PUBLIC COMMUNITY WATER SYSTEMS

2050 FORECAST WATER DEMANDS FOR PUBLIC COMMUNITY WATER SYSTEMS

Table of Contents

INTRODUCTION

One component of the 2024 New Jersey Statewide Water Supply Plan is the projection of water demands to the year 2050 for all public community water systems (PCWS) for which sufficient information is available. A spreadsheet model was developed for this purpose, incorporate results from additional spreadsheet models. The model is based upon and updates the methodology from a prior analysis (Van Abs et al., 2018) that provided PCWS demand projection to the year 2040.

Two demand starting points are used – the peak annual average year (from the DEP Deficit/Surplus Analysis) and the annual average demands from the years 2016 through 2020 (from the DEP New Jersey Water Tracking System). To facilitate planning, twelve scenarios are used.

- **Assumption of no change in residential per capita demands**
    1. 2050 Peak Demands: All PCWS retain their current water loss rate (using a reported value where available, or otherwise the median value from 2018-2019 for their respective geographic area (Bedrock and Coastal Plain geology).
    2. 2050 Peak Demands: All PCWS reach a water loss rate equivalent to the median value from 2018-2019 for their respective geographic area.
    3. 2050 Peak Demands: All PCWS reach a water loss rate equivalent to the 25th percentile value from 2018-2019 for their respective geographic area.
    4. 2050 Average Demands: All PCWS retain their current water loss rate (either a reported value or the median value from 2018-2019 for their respective geographic area.
    5. 2050 Average Annual Demands: All PCWS reach a water loss rate equivalent to the median value from 2018-2019 for their respective geographic area.
    6. 2050 Average Annual Demands: All PCWS reach a water loss rate equivalent to the 25th percentile value from 2018-2019 for their respective geographic area.
- **Assumption of a reduction in residential per capita demands by 10 percent by the year 2050**
    7. 2050 Peak Demands: All PCWS retain their current water loss rate (using a reported value where available, or otherwise the median value from 2018-2019 for their respective geographic area).
    8. 2050 Peak Demands: All PCWS reach a water loss rate equivalent to the median value from 2018-2019 for their respective geographic area.
    9. 2050 Peak Demands: All PCWS reach a water loss rate equivalent to the 25th percentile value from 2018-2019 for their respective geographic area.
    10. 2050 Average Annual Demands: All PCWS retain their current water loss rate (using a reported value, or otherwise the median value from 2018-2019 for their respective geographic area).
    11. 2050 Average Annual Demands: All PCWS reach a water loss rate equivalent to the median value from 2018-2019 for their respective geographic area.
    12. 2050 Average Annual Demands: All PCWS reach a water loss rate equivalent to the 25th percentile value from 2018-2019 for their respective geographic area.

The 10 percent reduction in per capita residential demands by the year 2050 is considered a very feasible level, given the ongoing trends for indoor residential demands and the improving technology for outdoor irrigation controllers. The model is constructed so that additional scenarios can be developed

with different assumptions for per capita residential demands, using the existing Scenarios 5 through 8 as a base.

Scenarios 1 and 2 have the highest 2050 demands for most PCWS, though some with very low recent water loss rates may show an increase in demands even without a population increase. Scenario 12 has the lowest 2050 demands, as most PCWS would need to achieve a significant reduction in water losses to meet the 25th percentile level.

This appendix provides a detailed methodology and structure for the various spreadsheet programs used in the 2050 PCWS demand forecast scenarios. The tabulated PCWS 2050 Demands Model results are provided at the end of the appendix for the largest PCWS that comprise 80% of total average annual demands for the years 2016-2020.

PCWS 2050 DEMANDS MODEL

The spreadsheet model is developed for 583 PCWS. However, 49 lack peak and average annual demand information from DEP, leaving results for 534 PCWS. The spreadsheet includes six worksheets.

- 2020 Demands
- 2050 No Cons (no reduction in residential per capita demands from 2020 assumptions)
- 2050 Conservation (10% reduction in residential per capita demands from 2020 assumptions)
- Comparisons (of annual demands for all scenarios, relative to total PCWS limits)
- Static Comparisons (Static version of “Comparisons” for analysis)

The first three columns of each worksheet is the same, with basic PCWS information, drawn from DEP’s Deficit/Surplus spreadsheet dated 8 June 2022.

A. PWSID Permit #
B. County
C. Name

The remaining columns change with the worksheet.

2020 DEMANDS WORKSHEET

This worksheet provides the foundation for the analysis, compiling available information for each PCWS using either system-specific information or, where direct information is not available, estimates from an analysis of PCWS with specific information. The columns and information sources are included below.

D. D/S Total Limits (mgd): This value is from Column “Total Limits (mgy)” in the DEP’s Deficit/Surplus spreadsheet dated 8 June 2022, translated to mgd.
E. D/S Peak Annual Demand (mgd): This value is from Column “Peak Annual Demand (mgd)” in the DEP’s Deficit/Surplus spreadsheet dated 8 June 2022.
F. D/S Peak Annual WL (mgd): This value is from the RIC Analysis spreadsheet described below, Compilations worksheet Column R “D/S Peak Annual WL (mgd)”.
G. D/S Peak Annual RES Demand (mgd): This value is from the RIC Analysis spreadsheet described below, Compilations worksheet Column S “D/S Peak Annual WL (mgd)”.
H. D/S Peak Annual IND Demand (mgd): This value is from the RIC Analysis spreadsheet described below, in Compilations worksheet Column T “D/S Peak Annual WL (mgd)”.

I. D/S Peak Annual COMM Demand (mgd): This value is from the RIC Analysis spreadsheet described below, Compilations worksheet Column U “D/S Peak Annual WL (mgd)”.
J. D/S Peak Annual IND/COMM Demand (mgd): This value is from the RIC Analysis spreadsheet described below, Compilations worksheet Column V “D/S Peak Annual WL (mgd)”. This value is “NA” if there are values in Columns H or I.
K. Check: This value is Column E minus the SUM of Columns F through J as a percentage of Column E (should equal zero).
L. D/S Peak Summer Demand (mgd): This value is Column E times Column X “Ratio Summer: Annual”.
M. D/S Peak Non-Summer Demand (mgd): This value is Column E times Column Y “Ratio Non-Summer: Annual”.
N. NJWaTr 2016-2020 Average Demand (mgd): This value is from the RIC Analysis spreadsheet described below, PCWS Demands Column H “NJWaTr 2016-2020 Average Demand (mgd)”.
O. NJWaTr 2016-2020 Average WL (mgd): This value is from the RIC Analysis spreadsheet described below, Compilations worksheet Column X “NJWaTr 2016-2020 Average WL (mgd)”.
P. NJWaTr 2016-2020 Average RES Demand (mgd): This value is from the RIC Analysis spreadsheet described below, Compilations worksheet Column Y “NJWaTr 2016-2020 Average RES Demand (mgd)”.
Q. NJWaTr 2016-2020 Average IND Demand (mgd): This value is from the RIC Analysis spreadsheet described below, Compilations worksheet Column Z “NJWaTr 2016-2020 Average IND Demand (mgd)”.
R. NJWaTr 2016-2020 Average COMM Demand (mgd): This value is from the RIC Analysis spreadsheet described below, Compilations worksheet Column AA “NJWaTr 2016-2020 Average COMM Demand (mgd)”.
S. NJWaTr 2016-2020 Average IND/COMM Demand (mgd): This value is from the RIC Analysis spreadsheet described below, Compilations worksheet Column AB “NJWaTr 2016-2020 Average IND/COMM Demand (mgd)”. This value is “NA” if there are values in Columns Q or R.
T. Check: This value is Column N minus the SUM of Columns 0 through S as a percentage of Column N (should equal zero).
U. Average Summer Demand (mgd): This value is Column N times Column X “Ratio Summer: Annual”.
V. Average Non-Summer Demand (mgd): This value is Column N times Column Y “Ratio Non-Summer: Annual”.
W. (Blank)
X. Ratio Summer: Annual: For PCWS with available monthly demand data, this value is from Column U of the “NJWaTr_PWSID_Demands_2011-2020v3 Analysis” spreadsheet, “PCWS Sort” worksheet, Column U “Ratio Summer: Annual”. All others use the relevant value for Bedrock or Coastal systems from Column AC “Median Ratio Summer: Annual”.
Y. Ratio Non-Summer: Annual: For PCWS with available monthly demand data, this value is from Column U of the “NJWaTr_PWSID_Demands_2011-2020v3 Analysis” spreadsheet, “PCWS Sort” worksheet, Column V “Ratio Non-Summer: Annual”. All others use the relevant value for Bedrock or Coastal systems from Column AD “Median Ratio Non-Summer: Annual”.
Z. Ratio Peak Annual: Average Annual: This value is Column E divided by Column N.

2050 NO CONS WORKSHEET

This worksheet builds the first six (No Conservation) scenarios. Three are focused on peak annual demands, with current water losses, "Nominal" water losses (i.e., equivalent to the recent median water loss percentage) or "Optimal" water losses (i.e., equivalent to the recent 25th percentile water loss percentage). The other three scenarios are focused on average annual demands, with the same three water loss options. The columns and information sources are included below.

D. Coastal Plain or Bedrock: CP for PCWS is where the service area is predominantly in the Coastal Plain (Inner and Outer). BR for PCWS is where the service area is predominantly in the Bedrock area (Piedmont, Highlands, Valley & Ridge).

PEAK SECTOR DEMANDS ALL SCENARIOS

E. RES 2050 (mgd): Residential 2020 Demands from "2020 Demands" Column G, multiplied by the percent population change from "PCWS 2050 Pop" Column Z.
F. IND 2050 (mgd): Industrial 2020 Demands from "2020 Demand" Column H.
G. COMM 2050 (mgd): Commercial 2020 Demands from "2020 Demands" Column I, multiplied by the percent population change from "PCWS 2050 Pop" Column Z.
H. IND/COMM 2050 (mgd): Where the values in "2020 Demands" Column J equals "NA", then this column is also "NA". Otherwise, it is the value from "2020 Demands" Column J, multiplied by the percent population change from "PCWS 2050 Pop" Column Z.

CURRENT WATER LOSS SCENARIO (PEAK)

I. WL CURRENT (mgd): Column J minus the sum of Columns E through H, yielding the water losses in 2050 based on continuation of the current (2020) water loss rate.
J. ANNUAL (mgd): Sum of Columns E through H, divided by (1 – "2020 Demands" Column F / "2020 Demands" Column E).
K. SUMMER (mgd): Column J times "2020 Demands" Column X "Ratio Summer: Annual".
L. NON-SUMMER (mgd): Column J times "2020 Demands" Column Y "Ratio Summer: Annual".

MEDIAN 2020 WATER LOSS FOR ALL PCWS (PEAK)

M. WL MEDIAN (mgd): Column N minus the sum of Columns E through H, yielding the water losses in 2050 based on the median 2020 water loss rate.
N. ANNUAL (mgd): Sum of Columns E through H, divided by either 0.88 (representing a Nominal Water Loss of 12% for Coastal Plain PCWS) or 0.83 (representing a Nominal Water Loss of 17% for Bedrock PCWS).
O. SUMMER (mgd): Column N times "2020 Demands" Column X "Ratio Summer: Annual".
P. NON-SUMMER (mgd): Column N times "2020 Demands" Column Y "Ratio Summer: Annual".

OPTIMAL (25TH PERCENTILE) WL FOR ALL PCWS (PEAK)

Q. WL OPTIMAL (mgd): Column R minus the sum of Columns E through H, yielding the water losses in 2050 based on the 25th percentile 2020 water loss rate.
R. ANNUAL (mgd): Sum of Columns E through H, divided by either 0.919 (representing an Optimal Water Loss of 8.1% for Coastal Plain PCWS) or 0.87 (representing an Optimal Water Loss of 13% for Bedrock PCWS).

S. SUMMER (mgd): Column R times "2020 Demands" Column X "Ratio Summer: Annual".
T. NON-SUMMER (mgd): Column R times "2020 Demands" Column Y "Ratio Summer: Annual".

AVERAGE SECTOR DEMANDS ALL SCENARIOS (AVERAGE ANNUAL)

U. RES 2050 (mgd): Residential 2020 Demands from "2020 Demands" Column P, multiplied by the percent population change from "PCWS 2050 Pop" Column Z.
V. IND 2050 (mgd): Industrial 2020 Demands from "2020 Demand" Column Q.
W. COMM 2050 (mgd): Commercial 2020 Demands from "2020 Demands" Column R, multiplied by the percent population change from "PCWS 2050 Pop" Column Z.
X. IND/COMM 2050 (mgd): Where the values in "2020 Demands" Column S equals "NA", this column is also "NA". Otherwise, it is the value from "2020 Demands" Column S, multiplied by the percent population change from "PCWS 2050 Pop" Column Z.

CURRENT WATER LOSS SCENARIO (AVERAGE ANNUAL)

Y. WL CURRENT (mgd): Column Z minus the sum of Columns U through X, yielding the water losses in 2050 based on continuation of the current (2020) water loss rate.
Z. ANNUAL (mgd): Sum of Columns U through X, divided by (1 – "2020 Demands" Column O / "2020 Demands" Column N).
AA. SUMMER (mgd): Column Z times "2020 Demands" Column X "Ratio Summer: Annual".
AB. NON-SUMMER (mgd): Column Z times "2020 Demands" Column Y "Ratio Summer: Annual".

MEDIAN 2020 WATER LOSS FOR ALL PCWS (AVERAGE ANNUAL)

AC. WL MEDIAN (mgd): Column AD minus the sum of Columns U through X, yielding the water losses in 2050 based on the median 2020 water loss rate.
AD. ANNUAL (mgd): Sum of Columns U through X, divided by either 0.88 (representing a Nominal Water Loss of 12% for Coastal Plain PCWS) or 0.83 (representing a Nominal Water Loss of 17% for Bedrock PCWS).
AE. SUMMER (mgd): Column AD times "2020 Demands" Column X "Ratio Summer: Annual".
AF. NON-SUMMER (mgd): Column AD times "2020 Demands" Column Y "Ratio Summer: Annual".

OPTIMAL (25TH PERCENTILE) WL FOR ALL PCWS (AVERAGE ANNUAL)

AG. WL OPTIMAL (mgd): Column AH minus the sum of Columns U through X, yielding the water losses in 2050 based on the 25th percentile 2020 water loss rate.
AH. ANNUAL (mgd): Sum of Columns U through X, divided by either 0.919 (representing an Optimal Water Loss of 8.1% for Coastal Plain PCWS) or 0.87 (representing an Optimal Water Loss of 13% for Bedrock PCWS).
AI. SUMMER (mgd): Column AH times "2020 Demands" Column X "Ratio Summer: Annual".
AJ. NON-SUMMER (mgd): Column AH times "2020 Demands" Column Y "Ratio Summer: Annual".

2050 CONSERVATION WORKSHEET

This worksheet builds the last four scenarios, where residential per capita demands are assumed to be 10 percent lower by 2050. Two are focused on peak annual demands, with either "Nominal" water losses (i.e., equivalent to the recent median water loss percentage) or "Optimal" water losses (i.e., equivalent to the recent 25th percentile water loss percentage). The other two scenarios are focused on average

annual demands, with the same two water loss options. The columns and information sources are the same as the “2050 No Cons” worksheet except that the values from the “2050 No Cons” worksheet are multiplied by 0.9 to represent a 10 percent reduction in residential per capita demand for the following columns:

PEAK SECTOR DEMANDS ALL SCENARIOS	AVERAGE SECTOR DEMANDS ALL SCENARIOS
E. RES 2050 (mgd)	U. RES 2050 (mgd)
G. COMM 2050 (mgd)	W. COMM 2050 (mgd)
H. IND/COMM 2050 (mgd)	X. IND/COMM 2050 (mgd)

COMPARISONS WORKSHEET

This worksheet compares the six “No Conservation” and “Conservation” scenarios. Rows highlighted in blue indicate that the PCWS is within the group of largest PCWS meeting 80% of total demands (using 2016-2020 averages); those also in bold are within the group of largest PCWS meeting 50% of total demands. The columns are included below.

A. PWSID Permit # (blue=Top 80%, bold=Top 50%)
B. County
C. Name
D. D/S Total Limits (mgd): from DEP Deficit/Surplus Analysis
E. POP CHANGE % 2020-2050: from PCWS 2050 Pop Worksheet, Column Z (see below)

PEAK ANNUAL, NO CONSERVATION

F. 2020 Peak (mgd): from 2020 Demands Worksheet, Column E
G. 2050 Peak, Current WL% (mgd): from 2050 No Cons Worksheet, Column J
H. 2050 Peak, Median WL% (mgd): from 2050 No Cons Worksheet, Column N
I. 2050 Peak, Optimal WL% (mgd): from 2050 No Cons Worksheet, Column R

PEAK ANNUAL, CONSERVATION

J. 2050 Peak, Current WL% (mgd): from 2050 Conservation Worksheet, Column J
K. 2050 Peak, Median WL% (mgd): from 2050 Conservation Worksheet, Column N
L. 2050 Peak, Optimal WL% (mgd): from 2050 Conservation Worksheet, Column R

AVERAGE ANNUAL, NO CONSERVATION

M. 2020 Annual Average (mgd): from 2020 Demands Worksheet, Column N
N. 2050 Average, Current WL% (mgd): from 2050 No Cons Worksheet, Column Z
O. 2050 Average, Median WL% (mgd): from 2050 No Cons Worksheet, Column AD
P. 2050 Average, Optimal WL% (mgd): from 2050 No Cons Worksheet, Column AH

AVERAGE ANNUAL, CONSERVATION

Q. 2050 Average, Current WL% (mgd): from 2050 Conservation Worksheet, Column Z
R. 2050 Average, Median WL% (mgd): from 2050 Conservation Worksheet, Column AD
S. 2050 Average, Optimal WL% (mgd): from 2050 Conservation Worksheet, Column AH
T. Blank

BALANCES

U. Remaining Capacity (mgd): This column compares the maximum value of columns F through S (i.e., all of the 2050 scenarios plus the 2020 peak and average values) to the Deficit/Surplus value in Column D. If Column D is “NA” then Column U is also “NA”. Some PCWS show “#DIV/0!” where demand data are lacking in the model.
V. Remaining Capacity %: This column expresses Column U as a percentage of Column D (again using “NA” or “#DIV/0!” where Column U is “NA” or “#DIV/0!”).
W. Top 90% of Avg Demands: Based on a separate analysis of annual average demands for the years 2016-2020 (Column M), 118 of the largest PCWS providing a total of 90% of total demands, and PCWS with Column M values of greater than 1.3 mgd are in that group. This column shows Y for PCWS within that group.
X. Top 80% of Avg Demands: Using the same approach for 80% of total demands, the breakpoint value is 2.525 mgd, with Y indicating that the PCWS is within that group (n=64).
Y. Top 50% of Avg Demands: Using the same approach for 50% of total demands, the breakpoint value is 14 mgd, with Y indicating that the PCWS is within that group (n=10).
Z. Top 90% With No Capacity: Where a PCWS within the top 90% group (Column W = “Y”) shows a value in Column V of less than zero (i.e., a deficit either exists or is forecast), then Column Z shows “CONCERN” to indicate a potential problem with meeting future demands. Otherwise, the column shows NA (or “#DIV/0!” where Column V is “#DIV/0!”). Of the 583 PCWS listed, 22 are flagged with “CONCERN”.
AA. NOTES: Provides explanation of issues regarding potential deficits (e.g., existing peak or average demands, peak future demands, average future demands, combination of future demands) or where the analysis has shown an unusual situation, such as where the annual average demands are greater than the peak demands from the Deficit/Surplus analysis.

STATIC COMPARISONS WORKSHEET

This worksheet is a copy of the values from the Comparisons worksheet to allow for sorting, statistical analysis, etc., without the potential for disturbing the links and equations in the Comparisons worksheet.

PCWS 2050 POP WORKSHEET

This worksheet incorporates the information derived from the dasymetric analysis of PCWS populations for the year 2050, which is used in the 2050 demand scenarios (no conservation and conservation). The values in Columns A through W are static, copied from the population model described in the next section (Column X is blank). The remaining columns are as follows:

Y. POP CHANGE 2020-2050: Column W (POP 2050 TOTAL) minus Column M (POP 2020 TOTAL);
Z. POP CHANGE % 2020-2050: the result in Column Y as a percentage of Column M; and
AA. % 2050 POP in HD/MD: sums the 2050 projected populations in the medium and high-density residential land use classes and expresses it as a percentage of the total 2050 PCWS population (Column W).

PCWS 2020 AND 2050 POPULATION ESTIMATES

This worksheet is a static output from a GIS-based dasymetric evaluation of PCWS populations using 2020 Census populations at the census block level, a GIS coverage of the census blocks, the DEP 2015

Land Use/Land Cover GIS coverage, and the DEP PCWS service area GIS coverage. The full methodology for the dasymetric analysis is explained in Van Abs et al. (2018). In summary, dasymetric analysis is a process of identifying the most likely location of populations within a geographic area (in this case, PCWS service areas) for each census area, using geographic information on relative land use densities for residential housing.

The same method is used to project the location of 2050 municipal populations within PCWS service areas. Where municipal and PCWS boundaries are the same, the result is intuitive for the full population, but the expected development density associated with a population increase will not necessarily be the same as for the existing PCWS population. Given recent development trends in New Jersey, the model assumes that development will be at higher densities unless the municipality is predominantly low-density.

It is understood that all dasymetric models have uncertainties. In this case, the major uncertainties for 2020 populations are the potential for incorrect census data at the block level and the use of land use density categories that include a wide range of possible situations (especially for high density, which can range from 5 units per acres to far higher levels). However, dasymetric evaluations have been used previously in New Jersey and elsewhere and provide better results than any other large-scale methods.

The spreadsheet columns are included below.

A. PWSID #: from DEP Deficit/Surplus Analysis
B. County: From DEP Deficit/Surplus Analysis, this is the primary location of the PCWS, recognizing that some PCWS have multi-county service areas.
C. PCWS Name: from DEP Deficit/Surplus Analysis
D. POP 2020 HD CP: The estimated 2020 PCWS population within high density residential land use areas in any portion of the PCWS service area located within the Coastal Plain.
E. POP 2020 MD CP: The estimated 2020 PCWS population within medium density residential land use areas in any portion of the PCWS service area located within the Coastal Plain.
F. POP 2020 LD CP: The estimated 2020 PCWS population within low and rural density residential land use areas in any portion of the PCWS service area located within the Coastal Plain.
G. POP 2020 HD PM: The estimated 2020 PCWS population within high density residential land use areas in any portion of the PCWS service area located within the Piedmont Province.
H. POP 2020 MD PM: The estimated 2020 PCWS population within medium density residential land use areas in any portion of the PCWS service area located within the Piedmont Province.
I. POP 2020 LD PM: The estimated 2020 PCWS population within low and residential density residential land use areas in any portion of the PCWS service area located within the Piedmont Province.
J. POP 2020 HD HL: The estimated 2020 PCWS population within high density residential land use areas in any portion of the PCWS service area located within the Highlands and Valley & Ridge Provinces.
K. POP 2020 MD HL: The estimated 2020 PCWS population within medium density residential land use areas in any portion of the PCWS service area located within the Highlands and Valley & Ridge Provinces.

L. POP 2020 LD HL: The estimated 2020 PCWS population within low and rural density residential land use areas in any portion of the PCWS service area located within the Highlands and Valley & Ridge Provinces.
M. POP 2020 TOTAL: the totals of Columns D through L
N. POP 2050 HD CP: The estimated 2020 PCWS population within high density residential land use areas in any portion of the PCWS service area located within the Coastal Plain.
O. POP 2050 MD CP: The estimated 2020 PCWS population within medium density residential land use areas in any portion of the PCWS service area located within the Coastal Plain.
P. POP 2050 LD CP: The estimated 2020 PCWS population within low and rural density residential land use areas in any portion of the PCWS service area located within the Coastal Plain.
Q. POP 2050 HD PM: The estimated 2020 PCWS population within high density residential land use areas in any portion of the PCWS service area located within the Piedmont Province.
R. POP 2050 MD PM: The estimated 2020 PCWS population within medium density residential land use areas in any portion of the PCWS service area located within the Piedmont Province.
S. POP 2050 LD PM: The estimated 2020 PCWS population within low and residential density residential land use areas in any portion of the PCWS service area located within the Piedmont Province.
T. POP 2050 HD HL: The estimated 2020 PCWS population within high density residential land use areas in any portion of the PCWS service area located within the Highlands and Valley & Ridge Provinces.
U. POP 2050 MD HL: The estimated 2020 PCWS population within medium density residential land use areas in any portion of the PCWS service area located within the Highlands and Valley & Ridge Provinces.
V. POP 2050 LD HL: The estimated 2020 PCWS population within low and rural density residential land use areas in any portion of the PCWS service area located within the Highlands and Valley & Ridge Provinces.
W. POP 2050 TOTAL: the totals of Columns N through V

PCWS 2016-2020 ANNUAL AVERAGE DEMANDS

This analysis is discussed in detail in Appendix G “Seasonal PCWS Demand Analysis: Statewide and Coastal” of the 2024 NJSWSP. The analysis used monthly and annual water demand data for the years 2016 through 2020 (most recent available) to derive annual average demands and monthly average demands; the latter are used to assess the ratio of summer (June through September) to non-summer demands for each PCWS. Appendix K includes a detailed description of the spreadsheet.

PCWS RESIDENTIAL, INDUSTRIAL AND COMMERCIAL DEMANDS

This analysis is discussed in Appendix F “Estimating New Jersey Residential, Industrial and Commercial Demands by Public Community Water System” of the 2024 NJSWSP. The analysis estimates the percentage of water demands from residential, industrial and commercial (including public uses) customers using information reported to DEP under the Water Quality Accountability Act (the percentage of water sales that are residential), and information voluntarily provided by PCWS regarding the percentage of water sales that are residential, industrial and commercial (RIC). The analysis evaluates

the statistical strength of relationships between those values and the percentage of the developed portions of PCWS service areas that are residential, industrial and commercial.

The spreadsheet “PCWS Residential, Industrial and Commercial Demands” provides eight worksheets providing the full analysis of the demand splits for each PCWS.

ALL PCWS RIC

This worksheet summarizes the results from the analyses elsewhere in the spreadsheet. The columns are included below.

A. PWSID Permit #: from DEP Deficit/Surplus Analysis
B. County: primary location of the PCWS, from DEP Deficit/Surplus Analysis
C. PCWS Name: from DEP Deficit/Surplus Analysis
D. D/S Total Limits (mgd): from DEP Deficit/Surplus Analysis
E. D/S Peak Annual Demand (mgd): from PCWS Demands worksheet, Column F
F. D/S Peak Annual WL (mgd): lookup value from Compilations worksheet, Column R
G. D/S Peak Annual RES Demand (mgd): lookup value from Compilations worksheet, Column S
H. D/S Peak Annual IND Demand (mgd): lookup value from Compilations worksheet, Column T
    - For most PCWS, this value is blank; only those PCWS that voluntarily supplied data on industrial demands have a value here.
I. D/S Peak Annual COMM Demand (mgd): lookup value from Compilations worksheet, Column U
    - For most PCWS, this value is blank; only those PCWS that voluntarily supplied data on commercial demands have a value here.
J. D/S Peak Annual IND/COMM Demand (mgd): lookup value from Compilations worksheet, Column V
    - Most PCWS have a value here, back-calculated using other known values. Only those PCWS that voluntarily supplied data on industrial and commercial demands show “NA” here.
K. NJWaTr 2016-2020 Average Demand (mgd): from PCWS Demands worksheet, Column J
L. NJWaTr 2016-2020 Average WL (mgd): lookup value from Compilations worksheet, Column X
M. NJWaTr 2016-2020 Average RES Demand (mgd): lookup value from Compilations worksheet, Column Y
N. NJWaTr 2016-2020 Average IND Demand (mgd): lookup value from Compilations worksheet, Column Z
    - For most PCWS, this value is blank; only those PCWS that voluntarily supplied data on industrial demands have a value here.
O. NJWaTr 2016-2020 Average COMM Demand (mgd): lookup value from Compilations worksheet, Column AA
    - For most PCWS, this value is blank; only those PCWS that voluntarily supplied data on commercial demands have a value here.
P. NJWaTr 2016-2020 Average IND/COMM Demand (mgd): lookup value from Compilations worksheet, Column AB
    - Most PCWS have a value here, back-calculated using other known values. Only those PCWS that voluntarily supplied data on industrial and commercial demands show “NA” here.

CALCULATIONS

This worksheet contains underlying calculations regarding the relationship between the percentage of water sales for residential, industrial and commercial (RIC) customers to the percentage of a PCWS service area that is in residential, industrial and commercial development (excluding all open space and water features). The results are used in other worksheets to develop RIC estimates for PCWS lacking water sales information for these customer classes.

A. PWSID: from DEP Deficit/Surplus Analysis
B. PCWS Name: from DEP Deficit/Surplus Analysis
C. WQAA RES Avg% 2019-2021: from DEP database on reported Residential water sales as a percent of total water sales (i.e., excluding water losses) for the years 2019 through 2021
    - In some cases, obvious reporting errors were omitted, resulting in reliance on fewer than three years of data.
D. Blank
E. DEMAND RES %: Values shown here represent voluntary data from a PCWS.
F. DEMAND IND %: Values shown here represent voluntary data from a PCWS.
G. DEMAND COMM %: Values shown here represent voluntary data from a PCWS.
H. Blank
I. LU RES %: percentage of residential land use (all classifications) within the developed portion of a PCWS service area
J. LU IND %: percentage of industrial land use (all classifications) within the developed portion of a PCWS service area
K. LU COMM %: percentage of commercial land use (all classifications including public facilities) within the developed portion of a PCWS service area
L. Blank
M. DEMAND RES %: If a value is provided in Column E, that value is shown here, otherwise the value from Column C is used. The assumption is that the more detailed PCWS information should be used where available.
N. DEMAND IND %: If a value is provided in Column F, that value is shown here.
O. DEMAND COMM %: If a value is provided in Column G, that value is shown here.
P. Blank
Q. Ratio RES Demand/LU: Column M divided by Column I, showing the relationship between residential demands and land use
R. Ratio IND Demand/LU: Column N divided by Column J, showing the relationship between industrial demands and land use. Blank where Column N is blank.
S. Ratio COMM Demand/LU: Column O divided by Column K, showing the relationship between commercial demands and land use. Blank where Column O is blank.
T. Ratio IND/COMM Demand/LU: Where Columns R and S are blank, this value is back-calculated as the ratio of non-residential sales (100 minus Column C, the residential sales) divided by the combined percentages of industrial and commercial land uses (Columns J and K).

ANALYSIS RIC DATA

This worksheet uses information provided voluntarily by PCWS regarding their percentage sales to residential, industrial and commercial users, compares these values to what the same PCWS reported to

DEP for percent residential sales, and assesses the relationship between the voluntary information on sales to the percentage of residential, industrial and commercial land uses within the developed portion of each PCWS service area. The analysis is reported in Appendix F. The worksheet columns are included below.

A. PWSID: from DEP Deficit/Surplus Analysis
B. PCWS Name: from DEP Deficit/Surplus Analysis
C. WQAA RES Avg% 2019-2021: from DEP database on reported Residential water sales as a percent of total water sales (i.e., excluding water losses) for the years 2019 through 2021
    - In some cases, obvious reporting errors were omitted, resulting in reliance on fewer than three years of data.
D. DEMAND RES %: The values shown here represent voluntary data from a PCWS.
E. DEMAND IND %: The values shown here represent voluntary data from a PCWS.
F. DEMAND COMM %: The values shown here represent voluntary data from a PCWS.
G. RES DIFF (WQAA-RIC): Column C (WQAA Residential demands) minus Column D (voluntary data)
    - In some cases, PCWS owners apparently reported residential demand percentages through the WQAA portal differently (e.g., as an average of all PCWS owned by the utility, rather than for each individual PCWS) than they did in the voluntary data. Because the voluntary data are more detailed, this analysis assumes that the voluntary data are more accurate.
H. LU RES %: percentage of residential land use (all classifications) within the developed portion of a PCWS service area
I. LU IND %: percentage of industrial land use (all classifications) within the developed portion of a PCWS service area
J. LU COMM %: percentage of commercial land use (all classifications including public facilities) within the developed portion of a PCWS service area
K. DEMAND RES %: equal to Column D
L. DEMAND IND %: equal to Column E unless zero, resulting in no value reported
M. DEMAND COMM %: equal to Column F unless zero, resulting in no value reported
N. Ratio RES Demand/LU: Column K divided by Column H, providing a ratio of percent residential sales to percent land use
O. Ratio IND Demand/LU: if Column L is greater than zero (blank) then Column L divided by Column I, providing a ratio of percent industrial sales to percent land use
P. Ratio COMM Demand/LU: if Column M is greater than zero (blank) then Column M divided by Column J, providing a ratio of percent commercial sales to percent land use

ANALYSIS R-ONLY DATA

This worksheet develops estimates of residential, industrial and commercial sales and ratios for sales to land uses, similar to the prior worksheet but using only the residential sales information provided through the WQAA data portal. The analysis is reported in Appendix F. The worksheet columns are included below.

A. PWSID: from DEP Deficit/Surplus Analysis
B. PCWS Name: from DEP Deficit/Surplus Analysis

C. WQAA RES Avg% 2019-2021: from DEP database on reported Residential water sales as a percent of total water sales (i.e., excluding water losses) for the years 2019 through 2021
   - In some cases, obvious reporting errors were omitted, resulting in reliance on fewer than three years of data.
D. LU RES %: percentage of residential land use (all classifications) within the developed portion of a PCWS service area
E. LU IND %: percentage of industrial land use (all classifications) within the developed portion of a PCWS service area
F. LU COMM %: percentage of commercial land use (all classifications including public facilities) within the developed portion of a PCWS service area
G. LU IND+ COMM %: Column E plus Column F, providing an aggregate industrial plus commercial land use percentage
H. IND/COMM SALES %: back-calculated as 100 minus Column C, in percent
I. Ratio RES Demand/LU: Column C divided by Column D, providing a ratio of percent residential sales to percent land use
J. Ratio IND/COMM Demand/LU: Column H divided by Column G, providing a ratio of percent industrial/commercial sales to percent industrial/commercial land use

COMPILATION

This worksheet estimates residential, industrial and commercial demands in mgd for peak and average demand years using information from the prior two worksheets ("Analysis RIC Data" and "Analysis R-only Data") for the combined set of 214 PCWS. It estimates the amount of water that does not result in water sales to RIC customers using the results of the Water Loss analysis from Appendix E.

The columns are included below.

A. PWSID: from DEP Deficit/Surplus Analysis
B. PCWS Name: from DEP Deficit/Surplus Analysis
C. WQAA RES Avg% 2019-2021: from DEP database on reported Residential water sales as a percent of total water sales (i.e., excluding water losses) for the years 2019 through 2021
   - In some cases, obvious reporting errors were omitted, resulting in reliance on fewer than three years of data.
D. DEMAND RES %: The pasted value is the WQAA reported value, except where voluntary data from a PCWS exists
E. DEMAND IND %: values shown here represent voluntary data from a PCWS
F. DEMAND COMM %: values shown here represent voluntary data from a PCWS
G. DEMAND IND/COMM %: Where no voluntary data from a PCWS exists, the value is 100-Column D, representing the non-residential component of water sales.
H. RES DIFF (WQAA-RIC): The pasted value from Column G of "Analysis RIC Data" worksheet
I. LU RES %: The pasted value from Column D of "Analysis R-only Data" worksheet
J. LU IND %: The pasted value from Column E of "Analysis R-only Data" worksheet
K. LU COMM %: The pasted value from Column F of "Analysis R-only Data" worksheet
L. LU IND+ COMM %: The pasted value from Column G of "Analysis R-only Data" worksheet
M. Ratio RES Demand/LU: The pasted value from Column I of "Analysis R-only Data" worksheet, except where a value exists for the PCWS in Column H of "Analysis RIC Data".

N. Ratio IND Demand/LU: The pasted value from Column O of "Analysis R-only Data" worksheet
O. Ratio COMM Demand/LU: The pasted value from Column J of "Analysis R-only Data" worksheet, except where a value exists for the PCWS in Column P of "Analysis R-only Data" worksheet
P. WL %: lookup value from "WL Analysis" worksheet, Column C.
Q. D/S Peak Annual Demand (mgd): lookup value from "PCWS Demands" worksheet, Column E
R. D/S Peak Annual WL (mgd): Column Q times Column P, in mgd
S. D/S Peak Annual RES Demand (mgd): Column Q minus Column R (providing the peak total demands not involved in water loss) times Column D, in mgd
T. D/S Peak Annual IND Demand (mgd): if there is a value in Column E, Column Q minus Column R (providing the peak total demands not involved in water loss) times Column E, in mgd
U. D/S Peak Annual COMM Demand (mgd): if there is a value in Column F, Column Q minus Column R (providing the peak total demands not involved in water loss) times Column F, in mgd
V. D/S Peak Annual IND/COMM Demand (mgd): if there is no value in Column U, Column Q minus Column R (providing the peak total demands not involved in water loss) times Column G, in mgd
W. NJWaTr 2016-2020 Average Demand (mgd): lookup value from "PCWS Demands" worksheet, Column J
X. NJWaTr 2016-2020 Average WL (mgd): Column W times Column P, in mgd
Y. NJWaTr 2016-2020 Average RES Demand (mgd): Column W minus Column X (providing the average total demands not involved in water loss), times Column D, in mgd
Z. NJWaTr 2016-2020 Average IND Demand (mgd): if there is a value in Column E, Column W minus Column X (providing the average total demands not involved in water loss) times Column E, in mgd
AA. NJWaTr 2016-2020 Average COMM Demand (mgd): if there is a value in Column F, Column W minus Column X (providing the average total demands not involved in water loss) times Column F, in mgd
AB. NJWaTr 2016-2020 Average IND/COMM Demand (mgd): if there is no value in Column AA, Column W minus Column X (providing the average total demands not involved in water loss) times Column G, in mgd

PCWS DEMANDS

This worksheet calculates estimated 2020 residential demands for all 583 PCWS in the model using the 2020 dasymetric population estimates by residential land use density from the "PCWS 2020 and 2050 Population Estimates" described above and the per capita residential demands from Van Abs et al. (2018).

A. PWSID Permit #: from DEP Deficit/Surplus Analysis
B. County: primary location of the PCWS, from DEP Deficit/Surplus Analysis
C. PCWS Name: from DEP Deficit/Surplus Analysis
D. D/S Total Limits (mgd): from DEP Deficit/Surplus Analysis
E. D/S Peak Annual Demand (mgd): from PCWS Demands worksheet, Column F
F. Peak Annual Demand Used (mgd): The value from Column E unless "NA", at which point the value is Column I times 1.49, which is the median ratio of peak to annual average demands for those PCWS with sufficient information.

G. NJWaTr 2016-2020 Average Demand (mgd): from DEP, as discussed in Appendix G "Seasonal PCWS Demand Analysis: Statewide and Coastal", as listed in the "PCWS 2016-2020 Annual Average Demands" spreadsheet
H. Average Demand by Pop Served (mgd): If Column G is "NA" (no available average demand) then this value is from Column AC.
I. Average Annual Demand Used (mgd): the value from Column G of H, whichever is not "NA"
J. POP 2020 HD CP: from "PCWS 2020 and 2050 Population Estimates" spreadsheet, Column D
K. POP 2020 MD CP: from "PCWS 2020 and 2050 Population Estimates" spreadsheet, Column E
L. POP 2020 LD CP: from "PCWS 2020 and 2050 Population Estimates" spreadsheet, Column F
M. POP 2020 HD PM: from "PCWS 2020 and 2050 Population Estimates" spreadsheet, Column G
N. POP 2020 MD PM: from "PCWS 2020 and 2050 Population Estimates" spreadsheet, Column H
O. POP 2020 LD PM: from "PCWS 2020 and 2050 Population Estimates" spreadsheet, Column I
P. POP 2020 HD HL: from "PCWS 2020 and 2050 Population Estimates" spreadsheet, Column J
Q. POP 2020 MD HL: from "PCWS 2020 and 2050 Population Estimates" spreadsheet, Column K
R. POP 2020 LD HL: from "PCWS 2020 and 2050 Population Estimates" spreadsheet, Column L
S. POP 2020 TOTAL: from "PCWS 2020 and 2050 Population Estimates" spreadsheet, Column M
T. HD CP (mgd): Column AF Row 2 from the residential per capita demand table (see below) times Column J, expressed as mgd
U. MD CP (mgd): Column AF Row 3 from the residential per capita demand table (see below) times Column K, expressed as mgd
V. LD CP (mgd): Column AF Row 4 from the residential per capita demand table (see below) times Column L, expressed as mgd
W. HD PM (mgd): Column AG Row 2 from the residential per capita demand table (see below) times Column M, expressed as mgd
X. MD PM (mgd): Column AG Row 3 from the residential per capita demand table (see below) times Column N, expressed as mgd
Y. LD PM (mgd): Column AG Row 4 from the residential per capita demand table (see below) times Column O, expressed as mgd
Z. HD HL (mgd): Column AH Row 2 from the residential per capita demand table (see below) times Column P, expressed as mgd
AA. MD HL (mgd): Column AH Row 3 from the residential per capita demand table (see below) times Column Q, expressed as mgd
AB. LD HL (mgd): Column AH Row 4 from the residential per capita demand table (see below) times Column R, expressed as mgd
AC. TOTAL (mgd): sum of Columns T through AB

The final portion of this worksheet is a table from Van Abs et al. (2018) providing the per capita water demands (annual, summer and non-summer) by geophysical region (Coastal Plain, Piedmont, Highlands and Valley & Ridge).

	AE	AF	AG	AH
Row	Residential Density/Region	Coastal Plain (CP)	Piedmont (PM)	Highlands and Ridge & Valley (HL)
2	High Density (HD) Annual	47.92	58.46	42.04

3	**Medium Density (MD) Annual**	59.04	61.2	53.52
4	**Low Density (LD) Annual**	93.27	73.95	61.09
5	**High Density (HD) Summer**	53.49	62.61	42.47
6	**Medium Density (MD) Summer**	75.88	76.62	59.42
7	**Low Density (LD) Summer**	141.05	108.92	81.75
8	**High Density (HD) Non-Summer**	45.13	56.27	41.82
9	**Medium Density (MD) Non-Summer**	50.59	53.17	50.62
10	**Low Density (LD) Non-Summer**	69.36	56.61	50.84

PCWS LULC

This worksheet is from the DEP 2015 Land Use/Land Cover GIS coverage, as used in the dasymetric population analysis discussed above in “PCWS 2020 and 2050 Population Estimates”.

A. PWSID Permit #: from DEP Deficit/Surplus Analysis
B. PCWS Name: from DEP Deficit/Surplus Analysis
C. RES% Served: the residential percentage of the developed portion of a PCWS service area (i.e., not including open space, wetlands and other non-developed areas)
D. IND% Served: the industrial percentage of the developed portion of a PCWS service area
E. COM% Served: the commercial percentage of the developed portion of a PCWS service area
F. IND/COMM% Served: the combined industrial and commercial percentage of the developed portion of a PCWS service area

WL ANALYSIS

The values in this spreadsheet are from the analysis described below.

A. PWSID Permit #: from DEP Deficit/Surplus Analysis
B. PCWS Name: from DEP Deficit/Surplus Analysis
C. Average 2018-2019 % WL or UFW
D. Source: DEP or Delaware River Basin Commission (DRBC)
E. Overlap with DEP UFW: If water loss information is available from both sources, the value is “Y”. The DRBC results were used in this case.
F. Coastal (C) or Bedrock (BR): location of the PCWS service area primarily in the Inner or Outer Coastal Plain (C) or the Piedmont, Highlands or Valley & Ridge regions (BR)
G. Utility Size (L>300 mgm, M>30 mgm, S>5<=30 mgm): based on 2016-2020 annual average water demands as reported by DEP
H. Total Limits (mgm) (From Col I, D/S Analysis 6/2022): PCWS total limits for supplying water based on the DEP Deficit/Surplus Analysis

PCWS WATER LOSS ANALYSIS

This analysis is discussed in detail in Appendix E “New Jersey Assessment of Water Losses for Public Community Water Systems” of the 2024 NJSWSP. The analysis is based on the spreadsheet “Combined UFW NRW Analysis Final”. There are three worksheets within the spreadsheet.

WL_UFWCOMBINE W DUPES

This worksheet contains information on water losses reported to both the DEP and Delaware River Basin Commission (DRBC); there are 319 values representing 234 PCWS, as 77 PCWS have submitted information to DEP for either Unaccounted For Water or Water Loss (using the AWWA methodology), and also reported Water Loss values to DRBC. The worksheet calculates the differences between the two reported values in those cases; the differences are split roughly half and half as to which is higher, and the median difference is a negative 1.2 percent. The columns are included below.

A. PWSID Permit #: from DEP Deficit/Surplus Analysis
B. PCWS Name: from DEP Deficit/Surplus Analysis
C. Average 2018-2019 % WL or UFW
D. Source: DEP or DRBC
E. Coastal (C) or Bedrock (BR): location of the PCWS service area primarily in the Inner or Outer Coastal Plain (C) or the Piedmont, Highlands or Valley & Ridge regions (BR)
F. Utility Size (L>300 mgm, M>30 mgm, S>5<=30 mgm): based on 2016-2020 annual average water demands as reported by DEP
G. Total Limits (mgm) (From Col I, D/S Analysis 6/2022): PCWS total limits for supplying water based on the DEP Deficit/Surplus Analysis
H. Overlap with DEP UFW: "Y" if data from the PCWS is available from both agencies
I. UFW-WL: for PCWS with "Y" in Column H, the DEP results minus the DRBC results

WL_UFWANALYSIS BY SIZE

This worksheet uses the DRBC data for PCWS that supplied results to both DEP and DRBC. For all other PCWS, it uses the available data from either DEP or DRBC. PCWS are sorted/grouped by Total Limits:

PCWS Size	Bedrock n=	Coastal n=	Total
Large	13	16	**29**
Medium	42	90	**132**
Small	35	38	**73**
Total	**90**	**144**	**234**

The analysis calculates the median and 25th percentile water losses as a percentage by Utility Size categories. Those medians are then tabulated as follows:

PCWS Size	Median Bedrock %NRW/UFW	Median Coastal %NRW/UFW	Ratio Bedrock to Coastal	25th Percentile Bedrock %NRW/UFW	25th Percentile Coastal %NRW/UFW	Ratio Bedrock to Coastal
Large	20.1	11.8	1.7	12.6	7.3	1.7
Medium	16.5	11.2	1.5	12.7	7.8	1.6
Small	17.1	13.7	1.3	13.0	9.2	1.4

The worksheet columns are included below.

A. PWSID Permit #: from DEP Deficit/Surplus Analysis
B. PCWS Name: from DEP Deficit/Surplus Analysis

C. Average 2018-2019 % WL or UFW
D. Source: indicates which data source was used (DEP or DRBC)
E. Overlap with DEP UFW: "Y" if data from the PCWS was available from both agencies, and so the DRBC data was used
F. Coastal (C) or Bedrock (BR): location of the PCWS service area primarily in the Inner or Outer Coastal Plain (C) or the Piedmont, Highlands or Valley & Ridge regions (BR)
G. Utility Size (L>300 mgm, M>30 mgm, S>5<=30 mgm): based on 2016-2020 annual average water demands as reported by DEP
H. Total Limits (mgm) (From Col I, D/S Analysis 6/2022): PCWS total limits for supplying water based on the DEP Deficit/Surplus Analysis
I. Median Loss %: for each Utility Size category
J. 25th Percentile Loss %: for each Utility Size category

WL_UFWANALYSIS BY REGION

This worksheet assesses water losses for all PCWS in each region, Coastal Plain (C) or Bedrock (BR), regardless of PCWS size. Because the statistical analysis (Appendix E) indicates that the Water Loss percentages are not statistically different between PCWS size classifications for each region, but are statistically different between regions, the values from this worksheet are used in the PCWS Demands Analysis.

The worksheet columns are included below.

A. PWSID Permit #: from DEP Deficit/Surplus Analysis
B. PCWS Name: from DEP Deficit/Surplus Analysis
C. Average 2018-2019 % WL or UFW
D. Source: indicates which data source was used (DEP or DRBC)
E. Overlap with DEP UFW: "Y" if data from the PCWS was available from both agencies, and so the DRBC data was used
F. Coastal (C) or Bedrock (BR): location of the PCWS service area primarily in the Inner or Outer Coastal Plain (C) or the Piedmont, Highlands or Valley & Ridge regions (BR)
G. Utility Size (L>300 mgm, M>30 mgm, S>5<=30 mgm): based on 2016-2020 annual average water demands as reported by DEP
H. Total Limits (mgm) (From Col I, D/S Analysis 6/2022): PCWS total limits for supplying water based on the DEP Deficit/Surplus Analysis
I. Median Loss %: for all PCWS by region (C) or (BR)
J. 25th Percentile Loss %: for all PCWS by region (C) or (BR)

PCWS 2050 WATER DEMAND PROJECTIONS FOR 64 PCWS WITH HIGHEST AVERAGE DEMANDS (NO CONSERVATION SCENARIOS)

BACKGROUND INFORMATION						PEAK ANNUAL, NO CONSERVATION				AVERAGE ANNUAL, NO CONSERVATION		
PWSID Permit # (bold=Top 50%)	County	Name	D/S Total Limits (mgd)	POP CHANGE % 2020-2050	2020 Peak (mgd)	2050 Peak, Current WL% (mgd)	2050 Peak, Median WL% (mgd)	2050 Peak, Optimal WL% (mgd)	2020 Annual Average (mgd)	2050 Average, Current WL% (mgd)	2050 Average, Median WL% (mgd)	2050 Average, Optimal WL% (mgd)
NJ0238001	**Bergen**	**Suez Water New Jersey - Haworth**	**133.499**	**11.8**	**102.882**	**115.016**	**108.667**	**103.670**	**103.860**	**116.109**	**109.700**	**104.656**
NJ2004002	**Union**	**New Jersey American Water Company - Raritan System**	**178.587**	**11.0**	**141.456**	**150.850**	**113.592**	**108.369**	**97.951**	**104.455**	**78.656**	**75.040**
NJ0714001	**Essex**	**Newark Water Department**	**106.011**	**10.9**	**76.117**	**81.324**	**61.532**	**58.703**	**52.557**	**56.153**	**42.487**	**40.533**
NJ1605002	**Passaic**	**Passaic Valley Water Commission**	**110.485**	**13.0**	**83.968**	**93.486**	**93.548**	**89.247**	**47.667**	**53.071**	**53.106**	**50.664**
NJ1345001	**Monmouth**	**New Jersey American Water Company - Coastal North**	**58.323**	**-1.4**	**47.268**	**45.399**	**43.710**	**41.855**	**39.158**	**37.610**	**36.211**	**34.674**
NJ0712001	**Essex**	**New Jersey American Water Company - Passaic Basin**	**62.807**	**5.1**	**36.495**	**36.922**	**35.530**	**33.897**	**32.234**	**32.612**	**31.382**	**29.939**
NJ0906001	**Hudson**	**Jersey City MUA**	**56.800**	**32.9**	**49.213**	**65.408**	**63.756**	**60.825**	**31.278**	**41.571**	**40.521**	**38.658**
NJ0327001	**Burlington**	**New Jersey American Water Company - Western Division**	**67.763**	**-0.7**	**42.932**	**41.513**	**42.890**	**41.070**	**28.272**	**27.337**	**28.244**	**27.046**
NJ1111001	**Mercer**	**Trenton Water Works**	**44.384**	**-0.1**	**28.779**	**28.757**	**27.353**	**26.096**	**26.405**	**26.385**	**25.097**	**23.943**
NJ1225001	**Middlesex**	**Middlesex Water Company**	**56.251**	**6.4**	**40.518**	**43.129**	**46.696**	**44.549**	**20.389**	**21.703**	**23.498**	**22.417**
NJ2004001	Union	Liberty Water Company	19.000	15.6	14.891	17.216	17.216	16.425	13.762	15.911	15.911	15.180
NJ1507005	Ocean	Suez Water New Jersey - Toms River	16.466	16.1	12.825	14.895	14.986	14.350	11.715	13.606	13.690	13.109
NJ0119002	Atlantic	New Jersey American Water Company - Atlantic	16.285	-2.4	11.268	10.992	11.582	11.090	10.904	10.636	11.207	10.731
NJ0408001	Camden	Camden City Water Department	18.981	0.8	10.825	10.911	8.094	7.751	9.875	9.954	7.384	7.071
NJ1214001	Middlesex	New Brunswick Water Department	17.900	25.4	12.102	15.170	13.780	13.146	9.811	12.299	11.172	10.658
NJ1204001	Middlesex	East Brunswick Water Utility	11.000	11.1	6.388	7.097	7.494	7.176	9.608	10.674	11.271	10.792
NJ0102001	Atlantic	Atlantic City MUA	23.438	9.8	9.356	10.277	9.313	8.918	8.553	9.395	8.514	8.152
NJ1424001	Morris	Southeast Morris County MUA	16.001	4.8	10.025	10.508	8.756	8.353	8.364	8.767	7.305	6.969
NJ0901001	Hudson	Bayonne City Water Department	10.500	4.4	8.395	8.762	8.762	8.359	7.341	7.661	7.661	7.309
NJ0251001	Bergen	Ridgewood Water Department	11.188	15.3	7.669	8.840	8.966	8.553	7.228	8.333	8.451	8.063
NJ1614001	Passaic	Wayne Township Division of Water	9.500	16.1	7.181	8.339	8.610	8.214	7.131	8.281	8.550	8.157
NJ0614003	Cumberland	Vineland City Water and Sewer Utility	9.986	0.6	7.983	8.030	8.451	8.092	6.808	6.849	7.208	6.902
NJ0705001	Essex	East Orange Water Commission	10.849	2.7	7.879	8.092	8.092	7.720	6.678	6.859	6.859	6.543
NJ0702001	Essex	Bloomfield Water Department	7.510	4.4	5.072	5.296	5.296	5.053	6.443	6.728	6.728	6.419
NJ1429001	Morris	Parsippany - Troy Hills	8.416	0.8	6.525	6.574	6.134	5.852	6.145	6.191	5.777	5.511
NJ0424001	Camden	Merchantville Pennsauken Water Commission	7.589	-2.2	6.364	6.224	6.216	5.953	5.764	5.638	5.631	5.392
NJ1209002	Middlesex	Old Bridge Township MUA	7.978	15.8	6.843	7.921	8.118	7.774	5.666	6.559	6.722	6.437
NJ1506001	Ocean	Brick Township MUA	16.068	17.5	8.454	9.937	9.823	9.406	5.632	6.621	6.544	6.267
NJ1205001	Middlesex	New Jersey American Water Company - Edison	8.450	-3.4	6.323	6.106	6.106	5.826	5.620	5.427	5.427	5.177
NJ1221004	Middlesex	South Brunswick Township Water Company	8.468	20.7	5.966	7.203	7.759	7.402	5.393	6.510	7.013	6.691
NJ1216001	Middlesex	Perth Amboy Department of Municipal Utilities	6.785	-0.2	5.510	5.500	4.368	4.167	5.274	5.265	4.181	3.989

BACKGROUND INFORMATION						PEAK ANNUAL, NO CONSERVATION				AVERAGE ANNUAL, NO CONSERVATION		
PWSID Permit # (bold=Top 50%)	County	Name	D/S Total Limits (mgd)	POP CHANGE % 2020-2050	2020 Peak (mgd)	2050 Peak, Current WL% (mgd)	2050 Peak, Median WL% (mgd)	2050 Peak, Optimal WL% (mgd)	2020 Annual Average (mgd)	2050 Average, Current WL% (mgd)	2050 Average, Median WL% (mgd)	2050 Average, Optimal WL% (mgd)
NJ1215001	Middlesex	North Brunswick Water Department	8.000	9.9	5.907	6.490	6.490	6.192	5.152	5.660	5.660	5.400
NJ1326001	Monmouth	Gordons Corner Water Company	5.203	4.9	4.959	5.203	5.255	5.032	5.039	5.287	5.340	5.114
NJ1213002	Middlesex	Monroe Township Utility Department	5.132	5.8	4.995	5.284	5.748	5.504	4.711	4.984	5.421	5.191
NJ0907001	Hudson	Kearny Town Water Department	11.250	13.2	6.131	6.943	6.943	6.624	4.586	5.194	5.194	4.955
NJ1808001	Somerset	Franklin Township Department Public Works	7.800	1.6	5.858	5.951	6.686	6.379	4.583	4.656	5.231	4.991
NJ0313001	Burlington	Evesham Township	4.601	3.1	3.914	4.034	4.466	4.276	4.520	4.659	5.158	4.939
NJ0324001	Burlington	Mount Laurel Township	4.972	2.6	4.475	4.591	4.558	4.365	4.481	4.597	4.564	4.370
NJ0713001	Essex	Montclair Water Department	7.289	9.6	4.890	5.358	5.177	4.939	4.354	4.771	4.610	4.398
NJ1514002	Ocean	Lakewood Township MUA	4.980	45.0	4.379	6.350	5.204	4.983	3.925	5.693	4.666	4.468
NJ0710001	Essex	Livingston Township Water Division	4.885	8.8	4.152	4.516	4.516	4.309	3.854	4.192	4.192	4.000
NJ1103001	Mercer	Aqua New Jersey - Hamilton Square	6.135	1.3	4.537	4.597	4.005	3.821	3.841	3.892	3.391	3.235
NJ0818004	Gloucester	Washington Township	5.982	0.8	4.234	4.270	4.747	4.546	3.799	3.831	4.260	4.079
NJ1316001	Monmouth	Freehold Township Water Department	5.510	7.9	4.109	4.432	4.645	4.448	3.793	4.091	4.288	4.106
NJ0514001	Cape May	Wildwood City Water Department	5.151	-2.2	3.599	3.521	3.521	3.371	3.735	3.653	3.653	3.498
NJ0701001	Essex	Belleville Township Water Department	4.200	13.3	3.733	4.228	4.228	4.033	3.644	4.128	4.128	3.938
NJ0323001	Burlington	New Jersey American Water Company - Mount Holly	6.923	5.3	4.984	5.046	5.318	5.092	3.620	3.664	3.862	3.698
NJ1339001	Monmouth	Shorelands Water Company	5.247	4.4	4.946	4.988	4.500	4.309	3.587	3.617	3.263	3.125
NJ0217001	Bergen	Fair Lawn Water Department	7.088	9.2	3.702	4.044	4.049	3.863	3.563	3.892	3.897	3.718
NJ0415002	Camden	Aqua New Jersey - Blackwood System	5.487	1.5	4.353	4.420	4.630	4.434	3.561	3.616	3.788	3.627
NJ2013001	Union	Suez Water New Jersey - Rahway	6.296	12.2	3.882	4.354	4.387	4.185	3.417	3.832	3.861	3.684
NJ0717001	Essex	Orange Water Department	5.250	3.4	3.914	4.047	3.255	3.106	3.286	3.398	2.733	2.607
NJ0716001	Essex	Nutley Water Department	3.000	5.5	3.320	3.502	3.502	3.341	3.156	3.329	3.329	3.176
NJ1511001	Ocean	Jackson Township MUA	4.829	37.6	3.500	4.815	5.082	4.867	3.150	4.334	4.574	4.380
NJ0610001	Cumberland	Millville Water Department	5.030	8.2	3.575	3.868	3.577	3.426	3.137	3.394	3.139	3.006
NJ0233001	Bergen	Mahwah Water Department	4.764	38.9	3.210	4.458	4.458	4.253	2.995	4.160	4.160	3.969
NJ2119001	Warren	Aqua New Jersey - Phillipsburg	4.795	3.7	3.875	4.017	3.831	3.655	2.988	3.097	2.954	2.818
NJ1328002	Monmouth	Marlboro Township MUA	7.318	-4.4	4.919	4.703	4.786	4.583	2.956	2.826	2.876	2.754
NJ0601001	Cumberland	Bridgeton City Water Department	4.110	13.3	3.109	3.522	3.704	3.547	2.915	3.303	3.473	3.326
NJ0322001	Burlington	Moorestown Water Department	3.199	12.9	3.075	3.471	3.551	3.400	2.795	3.155	3.227	3.090
NJ0436007	Camden	Winslow Township	4.897	2.6	2.920	2.995	3.009	2.881	2.663	2.732	2.745	2.628
NJ1409001	Morris	Dover Water Commission	3.159	0.6	2.889	2.907	2.424	2.313	2.598	2.614	2.180	2.080
NJ0221001	Bergen	Garfield City Water Department	5.452	10.7	2.675	2.961	2.961	2.825	2.571	2.845	2.845	2.715
NJ0338001	Burlington	Willingboro MUA	5.477	-0.9	3.793	3.758	3.354	3.212	2.530	2.507	2.238	2.143

PCWS 2050 WATER DEMAND PROJECTIONS FOR 64 PCWS WITH HIGHEST AVERAGE DEMANDS (CONSERVATION SCENARIOS)

BACKGROUND INFORMATION						PEAK ANNUAL, CONSERVATION				AVERAGE ANNUAL, CONSERVATION		
PWSID Permit # (bold=Top 50%)	County	Name	D/S Total Limits (mgd)	POP CHANGE % 2020-2050	2020 Peak (mgd)	2050 Peak, Current WL% (mgd)	2050 Peak, Median WL% (mgd)	2050 Peak, Optimal WL% (mgd)	2020 Annual Average (mgd)	2050 Average, Current WL% (mgd)	2050 Average, Median WL% (mgd)	2050 Average, Optimal WL% (mgd)
NJ0238001	**Bergen**	**Suez Water New Jersey - Haworth**	**133.499**	**11.8**	**102.882**	**103.514**	**97.800**	**93.303**	**103.860**	**104.498**	**98.730**	**94.190**
NJ2004002	**Union**	**New Jersey American Water Company - Raritan System**	**178.587**	**11.0**	**141.456**	**138.772**	**104.497**	**99.693**	**97.951**	**96.092**	**72.359**	**69.032**
NJ0714001	**Essex**	**Newark Water Department**	**106.011**	**10.9**	**76.117**	**76.014**	**57.514**	**54.870**	**52.557**	**52.486**	**39.712**	**37.886**
NJ1605002	**Passaic**	**Passaic Valley Water Commission**	**110.485**	**13.0**	**83.968**	**85.238**	**85.294**	**81.373**	**47.667**	**48.389**	**48.421**	**46.194**
NJ1345001	**Monmouth**	**New Jersey American Water Company - Coastal North**	**58.323**	**-1.4**	**47.268**	**40.864**	**39.344**	**37.675**	**39.158**	**33.853**	**32.594**	**31.211**
NJ0712001	**Essex**	**New Jersey American Water Company - Passaic Basin**	**62.807**	**5.1**	**36.495**	**33.302**	**32.047**	**30.573**	**32.234**	**29.414**	**28.305**	**27.004**
NJ0906001	**Hudson**	**Jersey City MUA**	**56.800**	**32.9**	**49.213**	**58.867**	**57.380**	**54.742**	**31.278**	**37.414**	**36.469**	**34.792**
NJ0327001	**Burlington**	**New Jersey American Water Company - Western Division**	**67.763**	**-0.7**	**42.932**	**37.381**	**38.622**	**36.983**	**28.272**	**24.617**	**25.434**	**24.354**
NJ1111001	**Mercer**	**Trenton Water Works**	**44.384**	**-0.1**	**28.779**	**25.881**	**24.618**	**23.486**	**26.405**	**23.746**	**22.587**	**21.549**
NJ1225001	**Middlesex**	**Middlesex Water Company**	**56.251**	**6.4**	**40.518**	**38.816**	**42.026**	**40.094**	**20.389**	**19.532**	**21.148**	**20.175**
NJ2004001	Union	Liberty Water Company	19.000	15.6	14.891	15.495	15.495	14.782	13.762	14.320	14.320	13.662
NJ1507005	Ocean	Suez Water New Jersey - Toms River	16.466	16.1	12.825	13.405	13.488	12.915	11.715	12.245	12.321	11.798
NJ0119002	Atlantic	New Jersey American Water Company - Atlantic	16.285	-2.4	11.268	9.894	10.425	9.982	10.904	9.574	10.088	9.659
NJ0408001	Camden	Camden City Water Department	18.981	0.8	10.825	9.820	7.285	6.975	9.875	8.959	6.645	6.363
NJ1214001	Middlesex	New Brunswick Water Department	17.900	25.4	12.102	13.653	12.402	11.832	9.811	11.069	10.055	9.592
NJ1204001	Middlesex	East Brunswick Water Utility	11.000	11.1	6.388	6.387	6.744	6.458	9.608	9.606	10.144	9.713
NJ0102001	Atlantic	Atlantic City MUA	23.438	9.8	9.356	9.249	8.382	8.026	8.553	8.456	7.662	7.337
NJ1424001	Morris	Southeast Morris County MUA	16.001	4.8	10.025	9.457	7.880	7.518	8.364	7.891	6.575	6.272
NJ0901001	Hudson	Bayonne City Water Department	10.500	4.4	8.395	7.886	7.886	7.523	7.341	6.895	6.895	6.578
NJ0251001	Bergen	Ridgewood Water Department	11.188	15.3	7.669	7.956	8.069	7.698	7.228	7.500	7.606	7.256
NJ1614001	Passaic	Wayne Township Division of Water	9.500	16.1	7.181	7.505	7.749	7.393	7.131	7.453	7.695	7.342
NJ0614003	Cumberland	Vineland City Water and Sewer Utility	9.986	0.6	7.983	7.227	7.606	7.283	6.808	6.164	6.487	6.212
NJ0705001	Essex	East Orange Water Commission	10.849	2.7	7.879	7.283	7.283	6.948	6.678	6.173	6.173	5.889
NJ0702001	Essex	Bloomfield Water Department	7.510	4.4	5.072	4.767	4.767	4.548	6.443	6.055	6.055	5.777
NJ1429001	Morris	Parsippany - Troy Hills	8.416	0.8	6.525	5.917	5.521	5.267	6.145	5.572	5.199	4.960
NJ0424001	Camden	Merchantville Pennsauken Water Commission	7.589	-2.2	6.364	5.602	5.595	5.357	5.764	5.074	5.068	4.853
NJ1209002	Middlesex	Old Bridge Township MUA	7.978	15.8	6.843	7.129	7.306	6.996	5.666	5.903	6.050	5.793
NJ1506001	Ocean	Brick Township MUA	16.068	17.5	8.454	8.944	8.841	8.465	5.632	5.959	5.890	5.640
NJ1205001	Middlesex	New Jersey American Water Company - Edison	8.450	-3.4	6.323	5.496	5.496	5.243	5.620	4.884	4.884	4.660
NJ1221004	Middlesex	South Brunswick Township Water Company	8.468	20.7	5.966	6.482	6.983	6.662	5.393	5.859	6.312	6.022
NJ1216001	Middlesex	Perth Amboy Department of Municipal Utilities	6.785	-0.2	5.510	4.950	3.931	3.750	5.274	4.738	3.763	3.590
NJ1215001	Middlesex	North Brunswick Water Department	8.000	9.9	5.907	5.841	5.841	5.573	5.152	5.094	5.094	4.860

BACKGROUND INFORMATION						PEAK ANNUAL, CONSERVATION				AVERAGE ANNUAL, CONSERVATION		
PWSID Permit # (bold=Top 50%)	County	Name	D/S Total Limits (mgd)	POP CHANGE % 2020-2050	2020 Peak (mgd)	2050 Peak, Current WL% (mgd)	2050 Peak, Median WL% (mgd)	2050 Peak, Optimal WL% (mgd)	2020 Annual Average (mgd)	2050 Average, Current WL% (mgd)	2050 Average, Median WL% (mgd)	2050 Average, Optimal WL% (mgd)
NJ1326001	Monmouth	Gordons Corner Water Company	5.203	4.9	4.959	4.682	4.730	4.529	5.039	4.758	4.806	4.602
NJ1213002	Middlesex	Monroe Township Utility Department	5.132	5.8	4.995	4.756	5.173	4.953	4.711	4.485	4.879	4.672
NJ0907001	Hudson	Kearny Town Water Department	11.250	13.2	6.131	6.249	6.249	5.962	4.586	4.674	4.674	4.459
NJ1808001	Somerset	Franklin Township Department Public Works	7.800	1.6	5.858	5.356	6.018	5.741	4.583	4.191	4.708	4.492
NJ0313001	Burlington	Evesham Township	4.601	3.1	3.914	3.630	4.019	3.849	4.520	4.193	4.642	4.445
NJ0324001	Burlington	Mount Laurel Township	4.972	2.6	4.475	4.132	4.102	3.928	4.481	4.138	4.108	3.933
NJ0713001	Essex	Montclair Water Department	7.289	9.6	4.890	4.822	4.660	4.445	4.354	4.294	4.149	3.958
NJ1514002	Ocean	Lakewood Township MUA	4.980	45.0	4.379	5.715	4.684	4.485	3.925	5.123	4.199	4.021
NJ0710001	Essex	Livingston Township Water Division	4.885	8.8	4.152	4.065	4.065	3.878	3.854	3.773	3.773	3.600
NJ1103001	Mercer	Aqua New Jersey - Hamilton Square	6.135	1.3	4.537	4.138	3.605	3.439	3.841	3.503	3.052	2.911
NJ0818004	Gloucester	Washington Township	5.982	0.8	4.234	3.843	4.273	4.091	3.799	3.448	3.834	3.671
NJ1316001	Monmouth	Freehold Township Water Department	5.510	7.9	4.109	3.989	4.180	4.003	3.793	3.682	3.859	3.695
NJ0514001	Cape May	Wildwood City Water Department	5.151	-2.2	3.599	3.169	3.169	3.034	3.735	3.288	3.288	3.148
NJ0701001	Essex	Belleville Township Water Department	4.200	13.3	3.733	3.805	3.805	3.630	3.644	3.715	3.715	3.544
NJ0323001	Burlington	New Jersey American Water Company - Mount Holly	6.923	5.3	4.984	4.544	4.789	4.586	3.620	3.300	3.478	3.330
NJ1339001	Monmouth	Shorelands Water Company	5.247	4.4	4.946	4.489	4.050	3.878	3.587	3.255	2.937	2.812
NJ0217001	Bergen	Fair Lawn Water Department	7.088	9.2	3.702	3.639	3.644	3.477	3.563	3.503	3.507	3.346
NJ0415002	Camden	Aqua New Jersey - Blackwood System	5.487	1.5	4.353	3.978	4.167	3.990	3.561	3.255	3.409	3.264
NJ2013001	Union	Suez Water New Jersey - Rahway	6.296	12.2	3.882	3.919	3.948	3.767	3.417	3.449	3.475	3.315
NJ0717001	Essex	Orange Water Department	5.250	3.4	3.914	3.643	2.930	2.795	3.286	3.058	2.460	2.347
NJ0716001	Essex	Nutley Water Department	3.000	5.5	3.320	3.152	3.152	3.007	3.156	2.996	2.996	2.858
NJ1511001	Ocean	Jackson Township MUA	4.829	37.6	3.500	4.334	4.574	4.380	3.150	3.901	4.117	3.942
NJ0610001	Cumberland	Millville Water Department	5.030	8.2	3.575	3.481	3.220	3.083	3.137	3.054	2.825	2.705
NJ0233001	Bergen	Mahwah Water Department	4.764	38.9	3.210	4.012	4.012	3.828	2.995	3.744	3.744	3.572
NJ2119001	Warren	Aqua New Jersey - Phillipsburg	4.795	3.7	3.875	3.615	3.448	3.290	2.988	2.788	2.659	2.536
NJ1328002	Monmouth	Marlboro Township MUA	7.318	-4.4	4.919	4.233	4.307	4.124	2.956	2.544	2.588	2.479
NJ0601001	Cumberland	Bridgeton City Water Department	4.110	13.3	3.109	3.170	3.334	3.192	2.915	2.973	3.126	2.993
NJ0322001	Burlington	Moorestown Water Department	3.199	12.9	3.075	3.124	3.196	3.060	2.795	2.839	2.905	2.781
NJ0436007	Camden	Winslow Township	4.897	2.6	2.920	2.696	2.708	2.593	2.663	2.459	2.470	2.365
NJ1409001	Morris	Dover Water Commission	3.159	0.6	2.889	2.617	2.182	2.081	2.598	2.353	1.962	1.872
NJ0221001	Bergen	Garfield City Water Department	5.452	10.7	2.675	2.665	2.665	2.542	2.571	2.561	2.561	2.443
NJ0338001	Burlington	Willingboro MUA	5.477	-0.9	3.793	3.383	3.019	2.890	2.530	2.257	2.014	1.928

State of New Jersey
Department of Environmental Protection

2024 NEW JERSEY STATEWIDE WATER SUPPLY PLAN

APPENDIX E

NEW JERSEY ASSESSMENT OF WATER LOSSES FOR PUBLIC COMMUNITY WATER SYSTEMS

NEW JERSEY ASSESSMENT OF WATER LOSSES FOR PUBLIC COMMUNITY WATER SYSTEMS

Table of Contents

NEW JERSEY ASSESSMENT OF WATER LOSSES FOR PUBLIC COMMUNITY WATER SYSTEMS

An analysis of water loss information collected by the DEP and DRBC concludes that public community water systems (PCWS) in Coastal Plain areas have consistently and significantly lower water losses than PCWS in Bedrock Provinces. Large, Medium and Small PCWS have somewhat different water loss rates, but this distinction is less (and less consistent) than that of the geophysical comparison.

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- Statistical Analysis: Jillian Drabik, PhD

OVERVIEW

A major factor in future water demand projections is the amount of water withdrawn from the raw water resources (e.g., reservoirs, rivers, aquifers) that is not delivered to metered customers (billed water) or other valid uses (e.g., unmetered, authorized demands such as firefighting, line cleaning). Measuring this “lost” water is complicated by several factors, including potential meter error, record-keeping errors, water theft, and the difficulty of measuring authorized but non-metered flows.

The water allocation regulations of DEP have long required analysis of “unaccounted for water” (UFW) at certain periods in a permit cycle. UFW is a simple measure comparing gallons of water billed (which can include unbilled metered water and unbilled authorized consumption such as firefighting) to the total water placed into water mains, resulting in UFW as a percentage (%UFW). DEP provided data for more than 200 public community water systems (PCWS) for the years 2016-2019, though not all PCWS provided UFW values for all four years.

The Delaware River Basin Commission requires use of the AWWA methodology for PCWS under their jurisdiction, providing a more detailed analysis of water volumes as billed, unbilled, apparent loss and real loss. DRBC provided data for 2018 through 2020 for almost 90 PCWS. The 2018 and 2019 audits used Version 5 of the AWWA methodology; these were used in this analysis for consistency with the DEP data years. The 2020 audits used a combination of Versions 5 and 6; they were not used. Again, not all PCWS provided water audits for all three years. It should be noted that the DRBC and DEP do not require that PCWS have their results independently verified or certified, raising possibilities for reporting errors.

Many PCWS in the DRBC dataset were also in the DEP data set. DRBC data were used wherever there is an overlap and the data were sufficient.[1] In both cases, detailed quality control reviews have not occurred, resulting in some anomalies within the data sets. For example, some PCWS reported negative results, which would indicate that more water was metered to customers than was placed into the distribution system, an obvious impossibility. In such cases, the results were excluded, along with results showing zero losses, which likewise is not feasible (all systems have some leakage). Second, some PCWS

[1] The Water Quality Accountability Act is expected to lead to a more detailed accounting using the Water Loss Audit methodology of the American Water Works Association (Manual 36), but that requirement is not in place. Even when implemented, many PCWS will require significant training on the AWWA methodology. a more detailed analysis of “non-revenue water” (NRW), which parses out the unmetered flows into authorized flows, apparent losses (e.g., meter and record-keeping errors), and real losses (e.g., theft and leakages from within the transmission system and service lines prior to the customer meter).

reported extraordinarily high levels of water losses, from 90% to 100%, which would indicate that nearly all or all water placed into the distribution system was lost; such results indicate poor use of the methodology, poor records, or other problems, and were also excluded. In both cases, the excluded results were so few that the resulting statistical analyses were not materially affected.

Given that the project seeks to understand how recent water demands are divided into residential, commercial and industrial sectors and “water losses”, average 2018/2019 results were used from both the DEP and DRBC data sets, unless no results were available for those years, at which point the average 2016/2017 results from DEP were used as a proxy. For both datasets separately, and then for the combined datasets, each PCWS was categorized by its service area’s primary geophysical location, either Bedrock Provinces (Valley & Ridge, Highlands and Piedmont) or Coastal Plain Provinces (Inner and Outer Coastal Plains), to test whether UFW/NRW results differed between the two areas. To further examine the results, the PCWS were also categorized by PCWS size based on the total water limits reported in DEP’s Deficit/Surplus Analysis from June 2022. Large PCWS were those with limits exceeding 300 mgm, Medium as greater than 30 mgm, and Small as greater than or equal to 5 mgm. Smaller systems than 5 mgm (less than 165,000 gallons per day) rarely provided information on UFW or NRW to the agencies; they were not included in the analysis. Statistical test results using t-tests and Mann-Whitney U Tests are provided in the appendix.[2]

RESULTS FROM THE DEP UFW INFORMATION

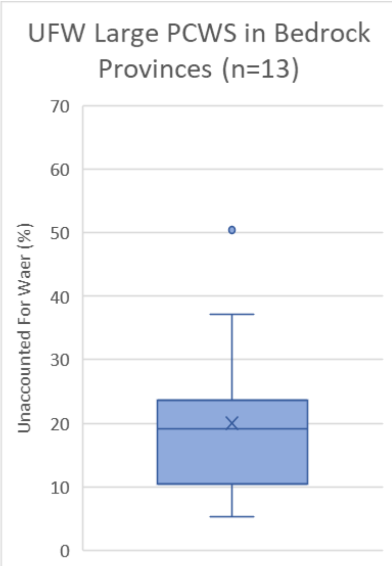
For all 234 PCWS in DEP dataset with usable data, basic statistics show the following results. Aside from the very large ranges between minimum and maximum values, the most useful point is that the medians and averages are not greatly different.

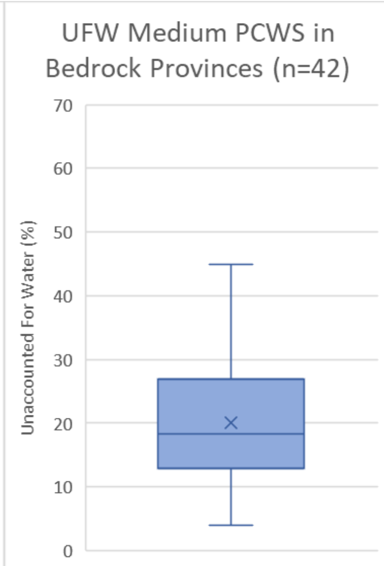
	UFW 2018 Calc %	UFW 2019 Calc %	Average 2016-2019 %UFW	Average 2018-2019 %UFW	% UFW Used
MAXIMUM	52.9	86.7	63.0	63.0	63.0
MINIMUM	0.2	0.1	0.1	0.1	0.1
MEDIAN	13.1	14.1	13.3	13.4	13.5
AVERAGE	15.1	16.2	15.8	15.4	15.5

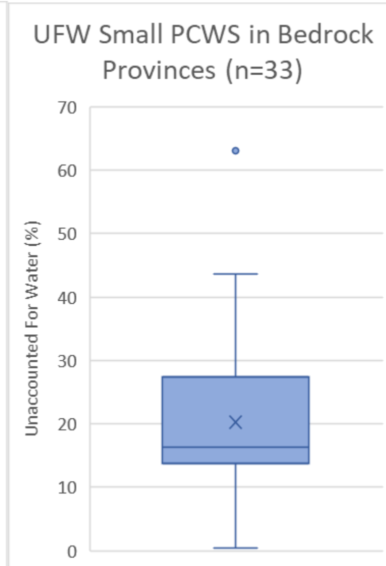
The results by PCWS category provide a different picture of UFW results. The PCWS in Bedrock Provinces have the following results by PCWS size. The blue box represents the PCWS from the 25th to 75th percentiles, the line within the box represents the median (the 50th percentile), the X represents the

[2] In the t-test the main (or null) hypothesis is considering if the mean of sample 1 is equal to the mean of sample 2. A non-significance finding indicates a failure to reject the hypothesis and the data provides support to conclude that there is no difference between the means. However, the t-test assumes normal distribution, which is not correct for the data sets. Therefore, the statistical analysis also includes Mann-Whitney U Tests, a statistical test that does not assume samples have a normal distribution. This is a nonparametric test of the null hypothesis that, for randomly selected values X and Y from two populations, the probability of X being greater than Y is equal to the probability of Y being greater than X.

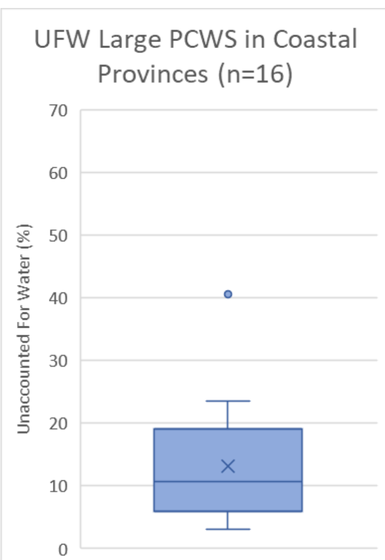
mean (average), the whiskers represent results within the top and bottom quartiles, with any points above or below the whiskers being outliers.[3] The number of PCWS is indicated by the "n".

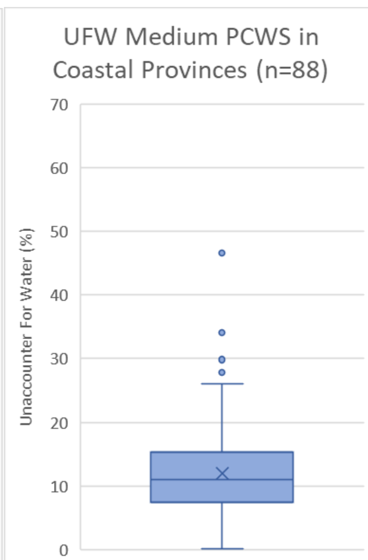


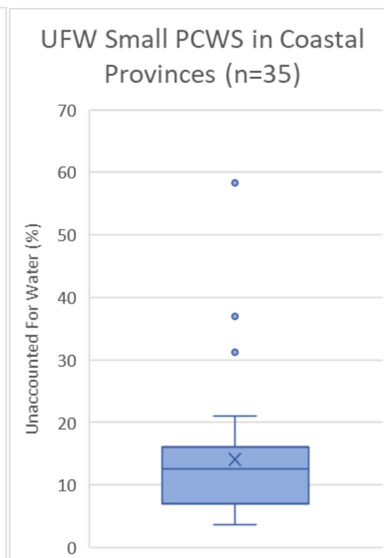




The PCWS in Coastal Plain Provinces have the following results by PCWS size.







Within these results, the following table shows the median and 25th percentile results for the three PCWS size categories in two geophysical settings. Two interesting patterns are shown. First, Large PCWS in the Bedrock grouping have a higher median than the Medium PCWS, which in turn have a higher median than the Small PCWS. In the Coastal group, the relationship is reversed, with the Small PCWS having the highest median. However, as discussed in the appendix, none of the differences between the three PCWS sizes within each geophysical setting is statistically significant. Second, the Coastal grouping

[3] These plots were developed in Microsoft Excel, which "uses the Tukey industry standard, which states that values are considered outliers only if they lie 1.5 times the length of the box (known as the interquartile range) from either end of the box." (Microsoft Excel Team Blog)

has much lower values for both median and 25th percentile. The ratio of median and 25th percentile values for Bedrock/Coastal PCWS is show for each PCWS size category, and ranges from two-thirds higher to nearly double for Bedrock, except for Small PCWS, where a roughly 30% higher result is seen for Bedrock. As discussed further in the appendix, this finding is statistically significant; the Coastal PCWS water loss results are different from those for the Bedrock PCWS. This finding is consistent with prior work from Van Abs, et al. (2018), showing a consistent finding that Coastal PCWS in general have lower total water losses as measured by UFW. As shown by the box and whisker plots, this also is true for the 75th percentile values for each PCWS size.

PCWS Size	Median Bedrock %UFW	Median Coastal %UFW	Ratio Bedrock to Coastal	25th Percentile Bedrock %UFW	25th Percentile Coastal %UFW	Ratio Bedrock to Coastal
Large	19.1	10.6	1.8	10.4	5.8	1.8
Medium	18.3	11.0	1.7	12.9	7.4	1.7
Small	16.3	12.6	1.3	13.8	7.0	2.0

RESULTS FROM THE DRBC NRW INFORMATION

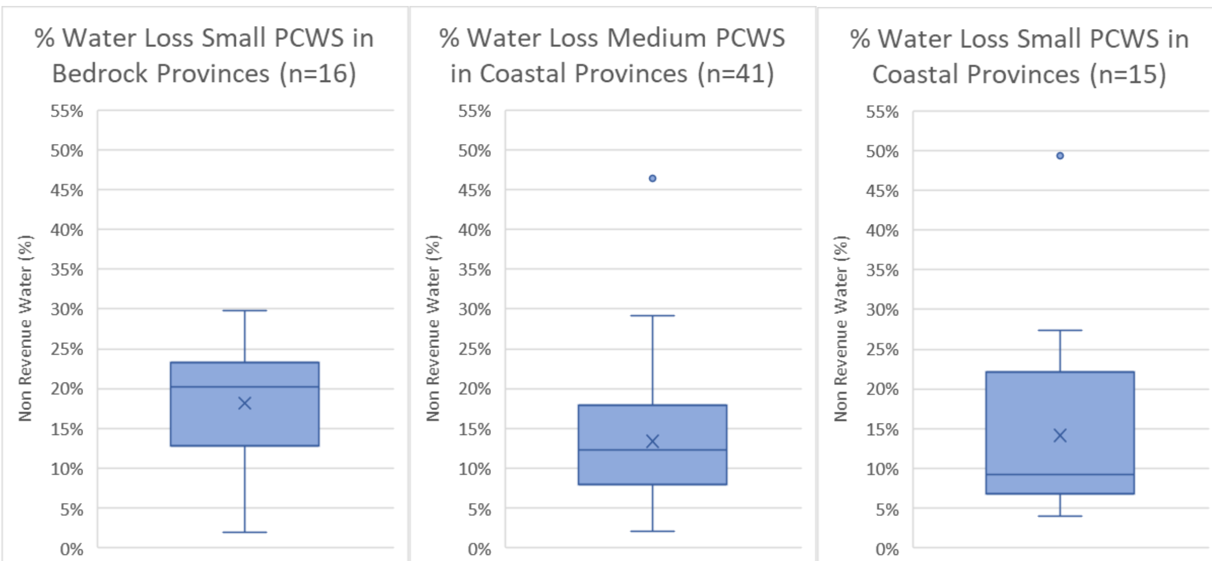
As discussed above, PCWS provide more detailed information about real, apparent and total water losses to the DRBC, using the AWWA methodology. The closest comparable value to DEP's UFW is the metric "Water Losses as % by Volume of Water Supplied" (shown here as % Water Loss or %WL), which is used in this analysis. The alternative approach would be to use Non-Revenue Water, but this metric includes metered and unmetered unbilled water, neither of which is a water loss. The following table provides information on the results from 2018 and 2019. As with the DEP UFW data set, the range from maximum to minimum are very large, especially in 2019, but the medians and averages are fairly close.

	2018 Calc % WL	2019 Calc % WL	Average 2018-2019 % WL
MAXIMUM	46.4%	86.7%	49.4%
MINIMUM	0.1%	0.7%	1.9%
MEDIAN	12.4%	10.8%	12.3%
AVERAGE	13.8%	14.5%	14.6%

As with the DEP UFW information, the DRBC data set was analyzed by PCWS size and geophysical province location. The data set is considerably smaller, with only 84 PCWS represented, instead of the more than 200 PCWS from the DEP data set. The portions of New Jersey within the Delaware River Basin are in general less densely populated than northern New Jersey, resulting in low representation among large systems (e.g., only one PCWS within the Large PCWS-Bedrock category), and the following table indicates categories for which less than 10 PCWS are represented. The ratios highlighted in yellow are based on a small number of reported values for one or both of the compared categories; they should not be used as definitive results.

PCWS Size	Median Bedrock %WL	Median Coastal %WL	Ratio Bedrock to Coastal	25th Percentile Bedrock %WL	25th Percentile Coastal %WL	Ratio Bedrock to Coastal
Large	21.1 (n=1)	10.6 (n=6)	2.0	NA	NA	NA
Medium	16.6 (n=4)	12.5 (n=41)	1.3	NA	10.0	NA
Small	20.5 (n=16)	9.6 (n=15)	2.1	15.1	8.1	1.9

Only three box and whisker plots were developed for this analysis, as the other three categories lacked sufficient data for analysis. As with the DEP data set, the 25th percentile values for Medium and Small Coastal Plain PCWS are markedly lower than for the Small Bedrock PCWS.

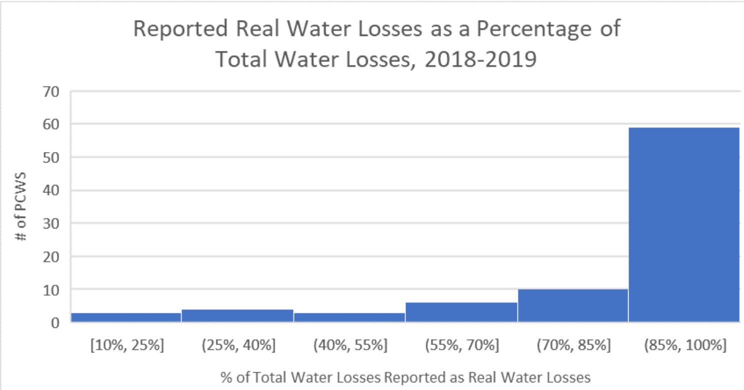


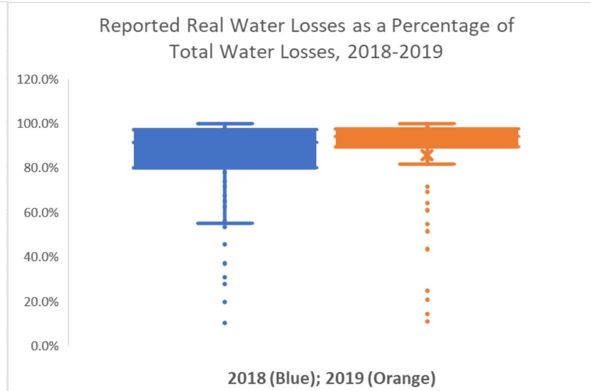
INSIGHTS FROM DRBC DATA SET

Information from the data set can be useful for understanding the value and limitations of this metric. First, the AWWA methodology provides opportunities for comparing real water losses to apparent water losses. An evaluation of these values across all reporting PCWS shows that in the 2018 reports, real losses comprised an average of 83% of total water losses, with a median of 91%. No results higher than the median were outliers, but there are seven low outliers below the lower whisker (i.e., less than 54.8%). For 2019 reports, the average was 85.5% and the median is 94%. For this year, again there were low outliers above the median, and the lower whisker is at 81.5%, a much tighter range of results. For 2019, 11 results were low outliers.

Therefore, real losses represent most of the total water losses, though some utilities indicated their real losses as low as 10%, a highly unlikely value. The results are shown in the following histogram for both years, and the box and whisker plots for each year. In many cases, the low values are from 2018, with the same PCWS showing much higher values in 2019 (e.g., a jump from 10.1% to 96.9%). The reverse is true for only a few PCWS (e.g., a drop from 67.3% to 24.5%). However, in some cases, very low values are reported for both 2018 and 2019, indicating either a major problem with apparent losses or poor

use of the AWWA methodology. It is likely that major year-to-year changes are a result of accounting differences in use of the methodology, rather than fundamental changes in real water losses. However, further inquiries with the specific water systems would be required to assess the reasons behind either consistently low results or highly variable results; such inquiries were beyond the scope of this project.





For the purposes of this report, where a utility reported values below the lower whisker for 2018 (54.8%), they were removed from the analysis if the water losses for that year were greatly different from the other year. Otherwise, a data entry error was assumed for apparent water losses. For example, one utility reported the following values:

Example Utility	2018	2019
Real Losses	6.7	41.3
Apparent Losses	53.7	1.3
Real as % of Total	11.1%	97.0%

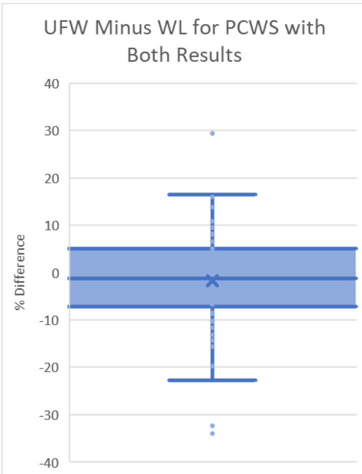
The probable error is in 2018, where the values were inverted. As both real and apparent losses are included within total water losses, this error does not change the values used in the water loss analysis above. Using this approach, either 2018 or 2019 results were removed from the analysis for 11 utilities, resulting in water loss values based on a single year.

Another AWWA water loss metric is the “real losses per service connection per day”, which for both years had an average value of just over 30 gallons per service connection per day; for both years, the median value was lower, at 27 gallons for 2018 and 22 gallons for 2019. For both years, the reported values ranged widely, from close to zero (an unlikely value that in every case was correlated with very low reported values for “real losses as a percentage of total water losses”) to highs of 213 gallons in 2018 and 144 gallons in 2019.

ANALYSIS OF COMBINED DEP AND DRBC DATA SETS

As noted above, the data sets were combined and compared, with DRBC Water Loss (WL) results being used instead of the DEP UFW results wherever a PCWS provided usable results to both agencies. As discussed in the appendix, there is no statistically significant difference between the two data sets for all PCWS that reported results to both DEP and DRBC, allowing for combination of the data sets for this purpose. Of the 84 PCWS that reported usable result to DRBC, 77 are also contained within the DEP data set. Of these, in 41 PCWS, the reported WL results exceeded the reported UFW results, while for 36

PCWS the UFW results exceeded the WL results. The distribution of WL/UFW results for all 234 records is shown in the following box and whisker plot, with the utility size and province breakdown in the table.

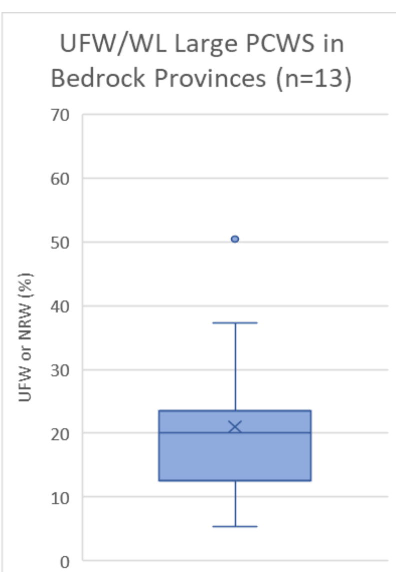


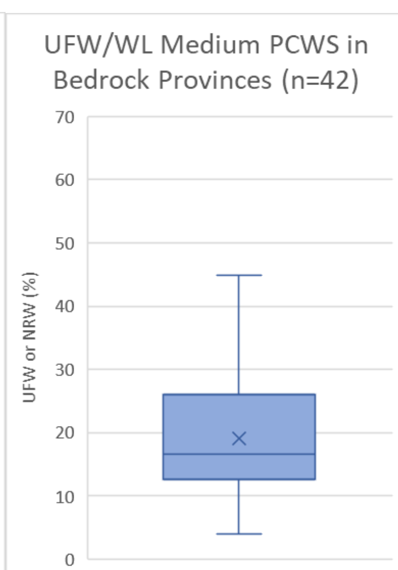
PCWS Size	Bedrock n=	Coastal n=	Total
Large	13	16	**29**
Medium	42	90	**132**
Small	35	38	**73**
Total	**90**	**144**	**234**

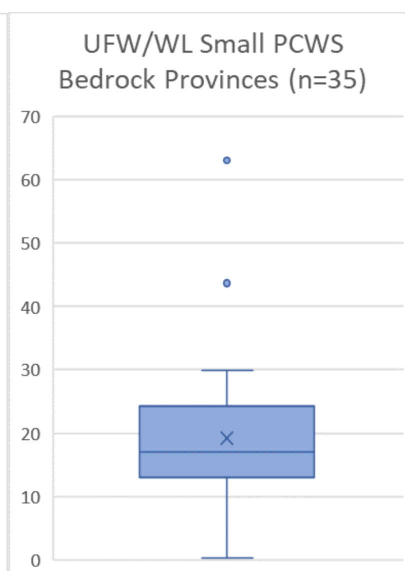
The overall results for 234 PCWS provide a median of 14.1% and an average of 15.9%. The breakdown results by category are shown in the following table. The results are somewhat different from the DEP UFW analysis due to the inclusion of DRBC WL values. Most importantly, the differences between Bedrock and Coastal Plain median and 25th percentile values are lower but still statistically significant.

PCWS Size	Median Bedrock %WL/UFW	Median Coastal %WL/UFW	Ratio Bedrock to Coastal	25th Percentile Bedrock %WL/UFW	25th Percentile Coastal %WL/UFW	Ratio Bedrock to Coastal
Large	20.1	11.8	1.7	12.6	7.3	1.7
Medium	16.5	11.2	1.5	12.7	7.8	1.6
Small	17.1	13.7	1.3	13.0	9.2	1.4

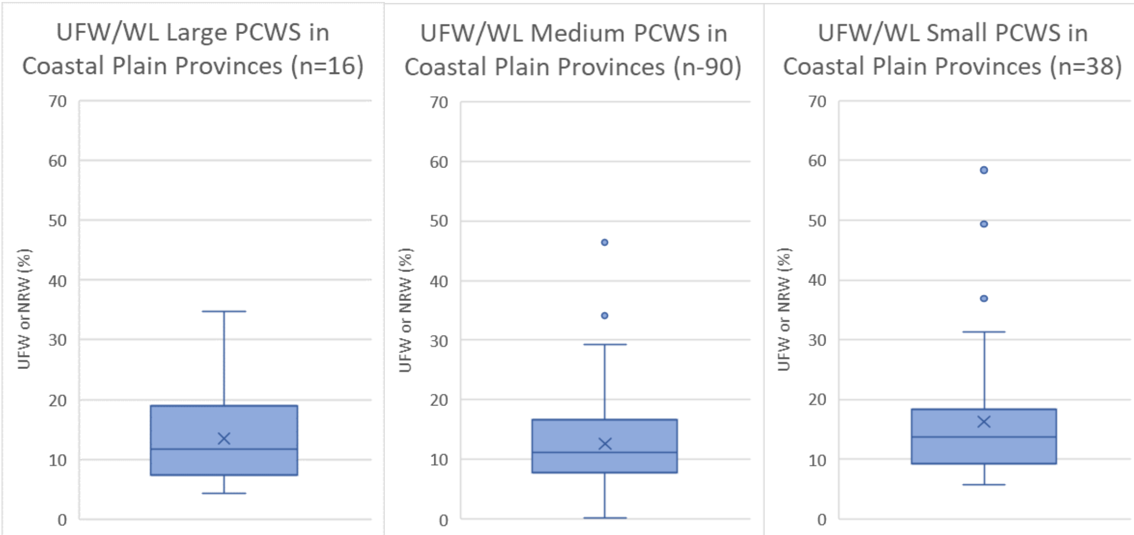
The box and whisker plots below provide additional information regarding the distribution of results for PCWS in the Bedrock Provinces.





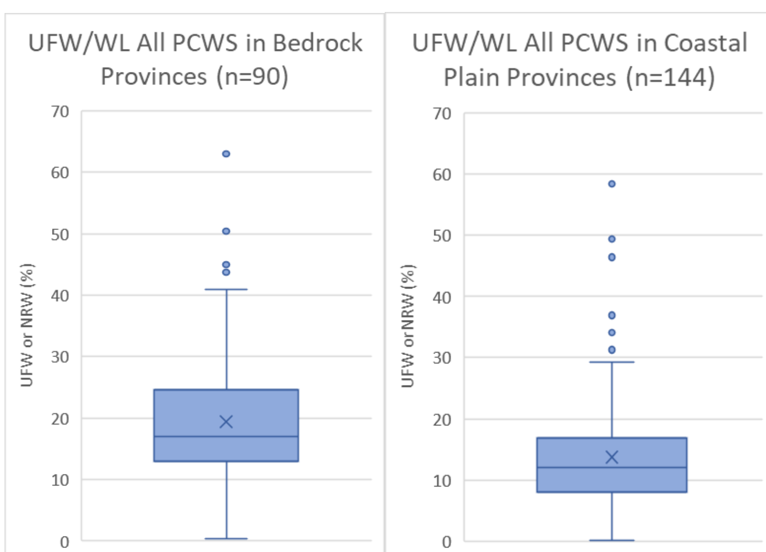


Similarly, the following box and whisker plots provide additional information regarding the distribution of results for PCWS in the Coastal Plain Provinces.



The Coastal Plain results are both lower and tighter (i.e., with a smaller range from 25th to 75th percentile) than the Bedrock results for large and especially medium PCWS sizes, but for small PCWS, the median, average and 25th percentile results do not differ greatly. The statistical analysis in the appendix indicates that the results by utility size within each geological region are not statistically different. Therefore, a final analysis of all utilities in the Coastal Plain and Bedrock regions are in the next table, along with the box and whisker plots.

PCWS Size	Median Bedrock %WL/UFW	Median Coastal %WL/UFW	Ratio Bedrock to Coastal	25th Percentile Bedrock %WL/UFW	25th Percentile Coastal %WL/UFW	Ratio Bedrock to Coastal
All	17.0	12.0	1.4	13.0	8.1	1.6



CONCLUSION

The most significant finding is that PCWS in the Bedrock Provinces exhibit higher results than those in the Coastal Plain Provinces across all PCWS size categories, for both median and 25th percentile results. The differences are statistically significant. This difference is most pronounced for the Large PCWS, and least pronounced for the Small PCWS.

Median results for water losses (WL) or unaccounted for water (UFW) among Medium and Small PCWS in the Bedrock Provinces are similar, with the Large PCWS having higher results, while the 25th percentile results are very close. Median results among Large, Medium and Small PCWS in the Coastal Plain Provinces are close, though the Small PCWS have somewhat higher results, while the 25th percentile results are very similar. However, statistical analyses indicate that the differences among PCWS size categories for each region are not statistically significant, and therefore the use of a single planning target by region is justified for the median (Nominal) and 25th percentile (Optimum) Water Loss.

The statistically significant differences between the Bedrock and Coastal Plain water losses provide a basis for having different planning targets in the two regions. In all cases, the real water losses will be somewhat lower. As shown with the DRBC data set, real water losses are estimated to comprise the vast majority of total water losses (average of 85.5% and median of 94%). The following table shows the results for WL/UFW and a Real Losses result that assumes real water losses are 90% of all water losses.

Water Loss Metric	Median Bedrock %NRW/UFW	Median Coastal %NRW/UFW	25th Percentile Bedrock %NRW/UFW	25th Percentile Coastal %NRW/UFW
All	17.0	12.0	13.0	8.1
Real Losses	15.3	10.8	11.7	7.3

The median results are used as an indicator of what the median utility currently achieves regarding water losses. The 25th percentile results are used as an indicator of what PCWS with robust asset management programs can achieve regarding real water losses. The consistent differences between PCWS in the two geophysical areas indicate that PCWS in the Bedrock Provinces may have a long-standing potential for higher real water losses, which will be a factor in 2050 water withdrawals from reservoirs, rivers and aquifers.

This research did not address <u>causes</u> for large differences in NRW and UFW between the regions. The consistent differences may be related to operational needs, such as multiple and higher pressure zones to overcome elevation differences within their services areas that Coastal Plain PCWS may not experience. Another possibility would be differences in distribution system ages, for which data are just becoming available through the Water Quality Accountability Act reporting process. Finally, some of the PCWS reported rates may be inaccurate. Further research would be needed to evaluate such issues. In addition, the AWWA water audit version 5 was used for the DRBC data set in 2018 and 2019. Version 6 is now being used; it may provide more accurate information for those PCWS using the method. However, because the method has only been in use for the 2020 data set from DRBC, this research relies on the most recent two years that use a consistent method. The year 2020 was also the onset of the Covid19 pandemic, which may cause significant differences in water losses from prior years, due to a possible shift in water demands between sectors, difficulties in PCWS O&M functions, and difficulties in the implementation of aggressive field monitoring and line repair/replacement for water leaks.

APPENDIX: STATISTICAL ANALYSES

The table below provides the findings of statistical tests that were conducted to detect significant differences in PCWS water loss across geological setting and PCWS size. Both water loss variables (%WL and % UFW) did not have a normal distribution, an assumption for t-tests that is especially important for conducting tests with smaller sample sizes (less than 20). For this reason, the table displays findings from the conducted t-tests along with the findings from the conducted Mann-Whitney U Tests, a statistical test that does not assume samples have a normal distribution. For comparative purposes, the table displays the t-test findings for each water loss test and its corresponding Mann-Whitney U test directly below it in italic. Greater confidence was placed in significant findings detected across both statistical tests. However, significant findings from only one test can warrant future analysis and may be the result of factors such as small sample size.

First, statistical tests were conducted using the 77 PCWS that reported to both the DEP and DRBC, to examine if reported water loss significantly differed between the two data sources used for this appendix's analysis (DRBC's %WL and DEP's %UFW). DRBC's average PCWS water loss (14.07) was slightly smaller than DEP's (14.44), and this difference was not found to be significant. Therefore, the two data sets can reasonably be combined for statewide analysis.

A series of statistical tests relying on both water loss metrics (%WL and %UFW) were conducted to examine significant differences in PCWS water loss across Bedrock and Coastal Plain geological regions. Overall, the difference in average water loss among all Bedrock and Coastal Plain systems was found to be significant in both conducted tests (t=4.21, p=0.00; U=8944, p=0.00). This finding was robust across both DRBC and DEP data sources. When considered separately, the difference in average %WL and %UFW water loss among Bedrock and Coastal Plain PCWSs was found to be significant in both sets of tests (DRBC: t=2.22, p=0.03; U=925, p=0.00: DEP: t=3.68, p=0.00; U=3851, p=0.00, respectively) (*See the first four statistical tests in table section: Water Loss-Source Specific (DRBC or DEP) for more information*).

Closer examination of the difference in average water loss (%WL and %UFW) among medium Bedrock and Coastal Plain systems was found to be significant (t=3.84, p=0.00; U=2680, p=0.00). Evidence was also detected of a significant difference in average water loss among large Bedrock and Coastal Plain systems (t=2.06, p=0.05 (marginal significance); U=153, p=0.03).

Several statistical tests were also conducted to determine significant differences in reported water loss among different sized PCWSs within a specific geological setting. However, none of these tests yielded significant findings.

In summary, the tests consistently found that water losses for PCWS were statistically different <u>between</u> the two geological regions, while the water losses for PCWS by utility size categories <u>within</u> each geologic region were not. The results indicate a profound effect of geological region on utility water loss results, but that planning targets for water losses within each geological region can be the same across utility sizes.

A final series of statistical tests was conducted to examine PCWS water loss with data provided by either DRBC (%WL) or DEP (%UFW). Similar to the significant differences in average water loss among medium and large Bedrock and Coastal Plain systems found in tests that relied on both water loss metrics, the

difference in average water loss among medium Bedrock and Coastal Plain systems using only DEP's %UFW data was also found to be significant (t=4.18, p=0.00; U=1378, p=0.00). The difference in average %UFW water loss among large Bedrock and Coastal Plain systems was found to be marginally significant in the conducted t-test (t=1.88; p=0.08) and not significant in the Mann-Whitney U Test (U=84; p=0.12). Although the sample sizes of some of the statistical tests were small (particularly, the tests examining large PCWSs), the results are consistent with the findings from the other methods of analysis presented in this appendix.

Table: Statistical Tests Conducted to Examine PCWS Water Loss

Water Loss Variable	Testing Populations	Sample Size	Mean	Variance (t-test)/ Standard Deviation (Mann-Whitney U Test)	t-Score (t-tests) / U Statistic (Mann-Whitney U Test)	P-Value
Water Loss by Data Source (PCWS Reporting to Both Agencies)						
%WL & %UFW (t-test)	DRBC	77	14.07	69.37	-0.26	0.80
	DEP	77	14.44	95.50		
(Mann-Whitney U Test)	*DRBC*	*77*	*14.07*	*8.33*	*3011*	*0.87*
	DEP	*77*	*14.44*	*9.77*		
Water Loss Across Topography (Bedrock & Coastal Plain)						
%WL & %UFW (t-test)	Bedrock	90	19.05	114.31	4.21	0.00**
	Coastal Plain	144	13.38	78.17		
(Mann-Whitney U Test)	*Bedrock*	*90*	*19.05*	*10.69*	*8944*	*0.00***
	Coastal Plain	*144*	*13.38*	*8.84*		
%WL & %UFW (t-test)	Bedrock (small)	35	18.49	133.21	0.97	0.33
	Coastal Plain (small)	38	15.84	137.98		
(Mann-Whitney U Test)	*Bedrock (small)*	*35*	*18.49*	*11.54*	*815*	*0.10**
	Coastal Plain (small)	*38*	*15.84*	*11.75*		
%WL & %UFW (t-test)	Bedrock (medium)	42	18.90	95.05	3.84	0.00**
	Coastal Plain (medium)	90	12.40	53.66		
(Mann-Whitney U Test)	*Bedrock (medium)*	*42*	*18.90*	*9.75*	*2680*	*0.00***
	Coastal Plain (medium)	*90*	*12.40*	*7.33*		
%WL & %UFW (t-test)	Bedrock (large)	13	21.01	140.47	2.06	0.05*
	Coastal Plain (large)	16	13.08	65.32		
(Mann-Whitney U Test)	*Bedrock (large)*	*13*	*21.01*	*11.85*	*153*	*0.03***
	Coastal Plain (large)	*16*	*13.08*	*8.08*		

Table: Statistical Tests Conducted to Examine PCWS Water Loss						
Water Loss Variable	**Testing Populations**	**Sample Size**	**Mean**	**Variance (t-test)/ Standard Deviation (Mann-Whitney U Test)**	**t-Score (t-tests) / U Statistic (Mann-Whitney U Test)**	**P-Value**
Water Loss by PCWS Size - within Topography Comparison (Bedrock or Coastal Plain)						
%WL & %UFW (t-test)	Bedrock (small)	35	18.49	133.21	-0.16	0.87
	Bedrock (medium)	42	18.90	95.05		
(Mann-Whitney U Test)	*Bedrock (small)*	*35*	*18.49*	*11.54*	*716*	*0.85*
	Bedrock (medium)	*42*	*18.90*	*9.75*		
%WL & %UFW (t-test)	Bedrock (medium)	42	18.90	95.05	-0.58	0.57
	Bedrock (large)	13	21.01	140.47		
(Mann-Whitney U Test)	*Bedrock (medium)*	*42*	*18.90*	*9.75*	*243*	*0.56*
	Bedrock (large)	*13*	*21.01*	*11.85*		
%WL & %UFW (t-test)	Bedrock (small)	35	18.49	133.21	-0.66	0.52
	Bedrock (large)	13	21.01	140.47		
(Mann-Whitney U Test)	*Bedrock (small)*	*35*	*18.49*	*11.54*	*197*	*0.49*
	Bedrock (large)	*13*	*21.01*	*11.85*		
%WL & %UFW (t-test)	Coastal Plain (small)	38	15.84	137.98	1.67	0.10
	Coastal Plain (medium)	90	12.40	53.66		
(Mann-Whitney U Test)	*Coastal Plain (small)*	*38*	*15.84*	*11.75*	*1951*	*0.21*
	Coastal Plain (medium)	*90*	*12.40*	*7.33*		
%WL & %UFW (t-test)	Coastal Plain (medium)	90	12.40	53.66	-0.31	0.76
	Coastal Plain (large)	16	13.08	65.32		
(Mann-Whitney U Test)	*Coastal Plain (medium)*	*90*	*12.40*	*7.33*	*718*	*0.99*
	Coastal Plain (large)	*16*	*13.08*	*8.08*		
%WL & %UFW (t-test)	Coastal Plain (small)	38	15.84	137.98	0.99	0.33
	Coastal Plain (large)	16	13.08	65.32		
(Mann-Whitney U Test)	*Coastal Plain (small)*	*38*	*15.84*	*11.75*	*345*	*0.45*
	Coastal Plain (large)	*16*	*13.08*	*8.08*		

Table: Statistical Tests Conducted to Examine PCWS Water Loss						
Water Loss Variable	**Testing Populations**	**Sample Size**	**Mean**	**Variance (t-test)/ Standard Deviation (Mann-Whitney U Test)**	**t-Score (t-tests) / U Statistic (Mann-Whitney U Test)**	**P-Value**
Water Loss-Source Specific (DRBC or DEP)						
%WL (DRBC) (t-test)	Bedrock	21	17.62	40.77	2.22	0.03**
	Coastal Plain	62	13.51	90.53		
(Mann-Whitney U Test)	*Bedrock*	*21*	*17.62*	*6.39*	*925*	*0.00***
	Coastal Plain	*62*	*13.52*	*9.52*		
%UFW (DEP) (t-test)	Bedrock	69	19.48	136.80	3.68	0.00**
	Coastal Plain	82	13.29	69.78		
(Mann-Whitney U Test)	*Bedrock*	*69*	*19.48*	*11.70*	*3851*	*0.00***
	Coastal Plain	*82*	*13.29*	*8.35*		
% WL (DRBC) (t-test)	Bedrock (small)	16	18.15	46.41	1.13	0.27
	Coastal Plain (small)	15	14.12	148.53		
(Mann-Whitney U Test)	*Bedrock (small)*	*16*	*18.15*	*6.81*	*170*	*0.05***
	Coastal Plain (small)	*15*	*14.12*	*12.19*		
%UFW (DEP) (t-test)	Bedrock (small)	19	18.78	212.75	0.44	0.66
	Coastal Plain (small)	23	16.96	134.22		
(Mann-Whitney U Test)	*Bedrock (small)*	19	18.78	14.59	227	0.84
	Coastal Plain (small)	23	16.96	11.59		
%UFW (DEP) (t-test)	Bedrock (medium)	38	19.35	101.33	4.18	0.00**
	Coastal Plain (medium)	49	11.57	38.83		
(Mann-Whitney U Test)	*Bedrock (medium)*	*38*	*19.35*	*10.07*	*1378*	*0.00***
	Coastal Plain (medium)	*49*	*11.57*	*6.23*		
%UFW (DEP) (t-test)	Bedrock (large)	12	21.01	153.24	1.88	0.08*
	Coastal Plain (large)	10	13.25	42.31		
(Mann-Whitney U Test)	*Bedrock (large)*	*12*	*21.01*	*12.38*	*84*	*0.12*
	Coastal Plain (large)	*10*	*13.25*	*6.51*		
***implies significance at alpha=0.10**						
****implies significance at alpha=0.05**						

State of New Jersey
Department of Environmental Protection

2024 NEW JERSEY STATEWIDE WATER SUPPLY PLAN

APPENDIX F

ESTIMATING NEW JERSEY RESIDENTIAL, INDUSTRIAL AND COMMERCIAL DEMANDS BY PUBLIC COMMUNITY WATER SYSTEM

ESTIMATING NEW JERSEY RESIDENTIAL, INDUSTRIAL AND COMMERCIAL DEMANDS BY PUBLIC COMMUNITY WATER SYSTEM

Table of Contents

ESTIMATING NEW JERSEY RESIDENTIAL, INDUSTRIAL AND COMMERCIAL DEMANDS BY PUBLIC COMMUNITY WATER SYSTEM

An analysis of the relationship between residential, industrial and commercial water demands and the percentage of residential, industrial and commercial land uses within the developed portion of public community water systems (PCWS) service areas in New Jersey. Using voluntary data from PCWS, there is a very strong positive relationship between the percentages of residential land use and water sales. Industrial demands do not show a correlation, perhaps in part because the water demands per unit area of industrial land uses range from low (e.g., warehouses) to high (e.g., beverage manufacturing). Finally, there is a strong moderate positive relationship between the percentages of commercial land use and water sales. Using DEP data from Water Quality Accountability Act reporting on percent residential water sales only, the relationship between percentages of residential land use and water sales is weaker overall but better for PCWS with high percentages of residential land use. These results were used to develop modeling assumptions in the 2050 demands model (see Appendix D) for PCWS that lack full data on residential, industrial and commercial water demands.

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OVERVIEW

The 2024 New Jersey Statewide Water Supply Plan includes multiple forecast scenarios for total, summer and non-summer demands by public community water system (PCWS) to the year 2050. These forecasts use two different starting points. One is the 2016-2020 annual average demand, and the other is the peak annual average demand from the 2016-2020 years.

PCWS demands have multiple components. For simplicity, metered demands can be split into residential, industrial and commercial (RIC) demands, and then a component for water losses (actual and real). Each component will have a different demand trend. Water losses are addressed in a separate white paper. This white paper discusses the methodology for assessing existing RIC demands based on available PCWS data and extrapolating the demands to PCWS for which utility-specific data are not available.

Existing residential demand data have been provided by nearly 200 PCWS in response to the Water Quality Accountability Act (WQAA), expressed as a percentage of total metered water sales. Separately, eight PCWS owners provided data voluntarily on the split between residential, industrial and commercial metered water sales (i.e., excluding water losses) for 34 PCWS. In both cases, residential information provided is dependent on how a PCWS classifies customers; specifically, one possible source of inconsistency is whether major apartment buildings or complexes are considered residential (based on the ultimate users) or commercial (based on the billed customer as a commercial entity). Also, some PCWS may have residential end users who live in mixed-use buildings that are charged as commercial

customers. For the purposes of this study, the assumption is that all residential end users are represented in the PCWS residential sales percentages.

The purpose of this analysis is to determine whether there is a sufficient correlation between the percentage of residential, industrial and commercial demands and the percentage of residential, industrial and commercial land uses within the PCWS service areas. Where a good correlation is identified, it can be used to estimate the RIC demand splits for PCWS lacking such data.

EVALUATION OF RIC WATER SALES (VOLUNTARY DATA)

Data on industrial and commercial demands are very limited, as few PCWS have submitted data on these sectors to DEP. For this project, DEP requested voluntary provision of RIC demand splits (as percentage of water sales) from PCWS that had significant industrial and commercial land uses (greater than 2% or 6%, respectively, of their service areas). Of the PCWS targeted, data were received from the systems listed below.

- New Jersey American Water (multiple)
- East Brunswick Water Utility
- Evesham Municipal Utility Authority (MUA)
- Passaic Valley Water Commission
- Ridgewood Water
- Sayreville Water Department
- South Brunswick Township Water Division
- Washington Township (Gloucester) MUA

In addition, RIC data for Newark Water & Sewer Department were used from the 2040 PCWS water demands study (Van Abs et al., 2018). Data were provided on the percentage of water sales (i.e., metered flows at the customer) for residential, industrial and commercial customer categories for a total of 35 PCWS. New Jersey American Water provided data both on PCWS with significant industrial and commercial customers (e.g., Raritan, Mount Holly, Atlantic County, Western/Delaware, Coastal North, Passaic) and most of their other PCWS, many of which are primarily residential in nature and one of which (International Trade Center) is primarily an office/industrial complex.

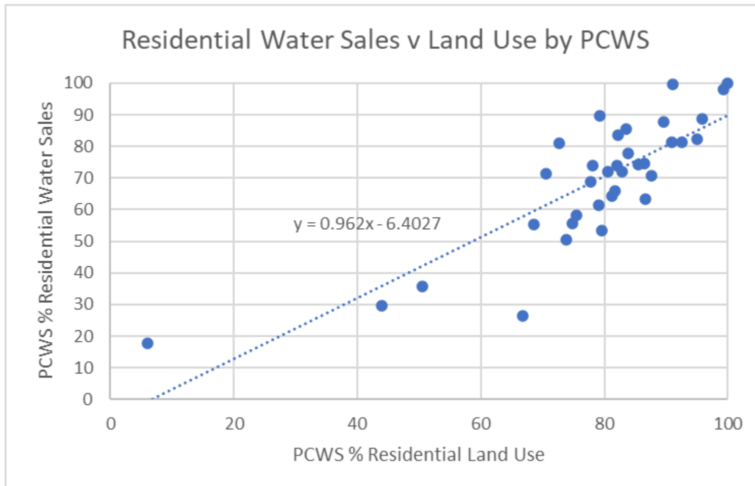
Many of these PCWS also reported the percentage of sales for residential customers under the WQAA reporting requirements. A comparison of the two residential values (WQAA submittals and voluntary data) showed little difference for some systems, while other showed larger differences. For those with major differences, some showed higher percentages of residential demands under the voluntary data than for the WQAA data. However, this difference is primarily due to New Jersey American having submitted a single percentage of residential demand for all PCWS (58.4%, a statewide weighted average) through the WQAA, whereas the values provided by New Jersey American for the RIC evaluation were for each PCWS separately. In other cases, the WQAA values are higher than the voluntary data; most notably Sayreville Water Department. Because the voluntary data were specifically requested and generated for this study, the assumption is that they are more reliable than the WQAA data, which provide no other data points for comparison.

The second step of the analysis is to compile residential, industrial and commercial land use information for each PCWS. This analysis is based on the 2015 LULC and was performed as part of the 2040 PCWS demands study (Van Abs et al., 2018). For this analysis, only the residential, industrial and commercial land use percentages are used, totaling 100%; in other words, land uses that are not served (e.g., wetlands, forests, barren land) are not included even though they are located within the overall service area. This information was added to the spreadsheet.

Using this information, the percentage of demands were compared to the percentage of sales for each PCWS.

RESIDENTIAL

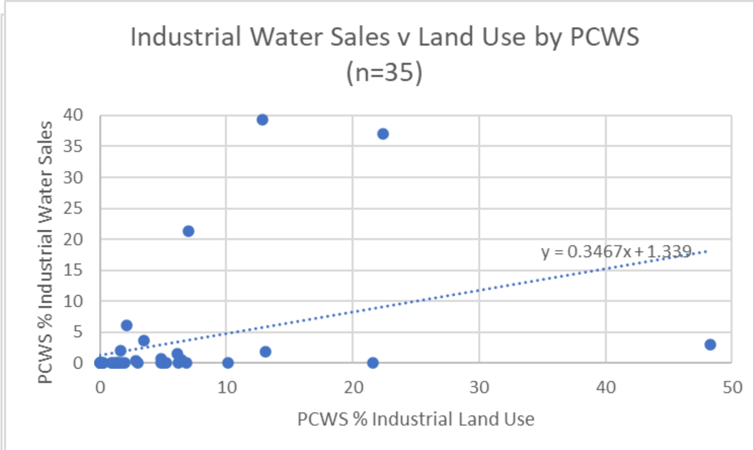
The following scattergram shows the relationship between residential water sales and land use by PCWS. Visually, the chart shows a strong relationship between the two factors. Only one outlier exists, New Jersey American-International Trade Center in the lower left corner, which is a primarily commercial/industrial PCWS with minimal residential land use or demands.



The Pearson correlation coefficient method was used to measure the relationship between PCWS percent water sales and percent land use across residential, industrial, and commercial sectors both with and without outliers. The coefficient measures the relationship between two variables with a number between -1 and 1, in which -1 indicates a very strong negative relationship (an increase in variable A is associated with a decrease in variable B), 0 indicates no relationship, and 1 indicates a very strong positive relationship (an increase in variable A is associated with an increase in variable B). Outliers were defined as all PCWS with % water sales or % land use greater than two standard deviations above or below the mean.

The Pearson correlation coefficient in the scattergram above is 0.831 (0.783 with outliers removed), which indicates a **very strong positive relationship** between PCWS percent of residential water sales and percent of service area with residential land use. A t-test was conducted to test if there is a statistically significant relationship between PCWS percent of residential water sales and percent of service area with residential land use. The p-value of this relationship both with and without outliers was less than 0.0001, indicating that PCWS percent of residential water sales has a statistically significant relationship with the percent of PCWS service area dedicated to residential land use. The best fit line for this scattergram (outliers included) is y = 0.962x – 6.4027. (With the outliers removed, the best fit line for this scattergram is y = 1.1845x - 24.151.)

INDUSTRIAL



The following scattergrams show the relationship between industrial water sales and land use by PCWS using two different groups. The first chart is for all 35 PCWS in the worksheet, while the second chart is for the 19 PCWS with greater than 2% industrial land in the service area. In both cases, a clear correlation between demands and land use is not visually obvious. Some major outliers exist. The highest industrial demands are in Sayreville (39.3%) and Newark (37.1%); in both cases, industrial land coverage is in the middle of the scale at 12.8% and 22.4%, respectively, which indicates a concentration of industry with significant water demands. New Jersey American-Raritan System has a high industrial demand (21.3%) with a lower industrial land use (7.0%), indicating an even stronger concentration of water-intensive industry.

Conversely, South Brunswick has an industrial demand of essentially zero, despite industrial land use at 21.6%; the township is a major warehousing hub along the New Jersey Turnpike. Likewise, New Jersey American-Logan System has a small industrial demand (2.7%) compared to a very high industrial land base (48.3%).

Several major difficulties exist with analyzing industrial demands. First, industrial land uses are usually a small percentage of total service areas, except for PCWS that were built to serve an industrial zone. Second, industrial land uses can range from high-demand manufacturing facilities to low-demand warehousing. Third, industrial demands have shifted significantly since the 1980s, with a great increase in warehousing and a decrease in high-demand manufacturing. Fourth, some industries are self-supplied for part or all of their water needs, and yet may be located within PCWS service areas. For these reasons, assessing industrial demands is the most complex and difficult component of RIC analysis.

In comparison to the residential scattergram, the positive relationship between all PCWS percent industrial water sales and percent of service area with industrial land use was much weaker, with a Pearson correlation coefficient of 0.339. However, PCWS percent industrial water sales were found to have a statistically significant relationship with PCWS industrial land use, with a p-value of 0.046. With the removal of outliers, the Pearson correlation coefficient decreased to 0.138, indicating a very weak relationship between industrial water sales and land use. Statistical testing with the removal of outliers resulted in a non-significant relationship (p=0.453) between industrial water sales and industrial land use, leading to the conclusion that there is not enough evidence to suggest that industrial water sales and land use are associated with each other. The best fit line for this scattergram (outliers included) is y = 0.3467x + 1.339. With the removal of outliers, the best fit line for this scattergram is y = 0.1165x + 0.7585.

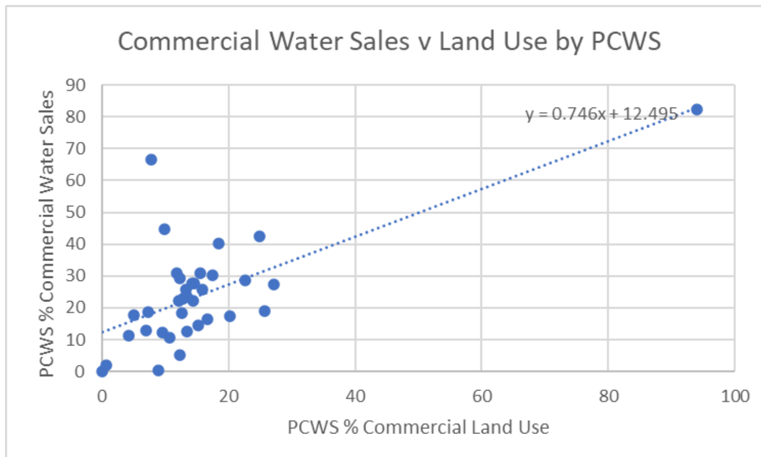
The scattergram with only PCWS with greater than two percent industrial land use in their service area indicates an even weaker relationship between PCWS percent industrial water sales and industrial land use compared to the scattergram with all PCWS included. The Pearson correlation coefficient is 0.231,

indicating a relatively weak positive relationship between percent industrial water sales and industrial land use. This relationship was also found to be not significant (p=0.328). With the removal of outliers, the Pearson correlation coefficient became negative and indicated almost no relationship between industrial water demand and industrial land use (-0.049), which was also found to be nonsignificant (p=0.851). The best fit line for this scattergram (outliers included) is y = 0.2585x + 3.271. With the removal of the outliers, the best fit line for this scattergram is y = -0.0531x + 2.4829.

Based on these statistical tests, the correlation between industrial demands and land uses is not strong, making it difficult to extrapolate these results to PCWS for which no industrial demands are available.

COMMERCIAL

The following scattergram shows the relationship between commercial water sales and land use by PCWS. Visually, the chart shows a solid relationship between the two factors. As with the chart for residential demands, only one outlier exists, New Jersey American-International Trade Center, which is a primarily commercial PCWS with minimal residential land use or demands. However, while that PCWS is an extreme example, it is roughly in line with the other data points.



PCWS percent commercial water sales and percent commercial land use was found to have a **strong moderate positive relationship**, with a Pearson correlation coefficient of 0.671 (0.557 with outliers removed). The t-test findings also indicated that the relationship between PCWS commercial water sales and commercial land use is statistically significant with a p-value of less than 0.0001. With the outliers removed, t-test results still provided enough evidence to find a statistically significant relationship between commercial water sales and commercial land use (p=0.001). The best fit line for this scattergram (outliers included) is y = 0.746x + 12.495. With the removal of outliers, the best fit line for this scattergram is y = 0.9711x + 8.0473.

The statistical tests for commercial demands, when combined with the even stronger relationship for residential demands, provide a solid foundation for estimating these demands for PCWS that lack RIC data, where the industrial land uses in the PCWS service area are minimal.

EVALUATION OF WQAA REPORTED RESIDENTIAL WATER SALES

As part of annual WQAA reporting, DEP requires PCWS to submit information on the percentage of water sales for residential customers. As with the voluntary data, the definition of residential customers resides with the PCWS. As noted previously, for the purposes of this study, the assumption is that all residential end users are represented in the PCWS residential sales percentages.

Data for 211 PCWS were submitted to DEP and provided for this analysis; after elimination of data from the PCWS for which voluntary data were provided, 179 PCWS were used for this part of the analysis. Of these, two were then modified as apparent data entry errors (Harrison Water Department, from 0.6%

residential to 60%, and West Cape May from 6.3% to 63%). A few others are questionable because of the large disparity between the residential sales and residential land uses (e.g., Berlin Water, Ocean Gate Water, and Veolia New Jersey for both Olde Milford Estates and Bald Eagle Commons). For example, Ocean Gate Water reported 20% residential demand, but the service area is 95% residential. However, the causes were not readily apparent and therefore the values were left as reported.

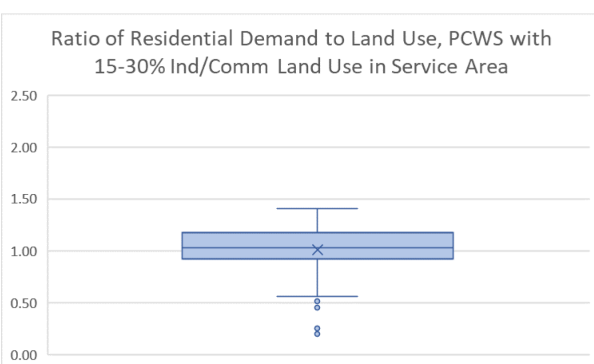
For this dataset, no information was provided on industrial and commercial demands. Therefore, the assumption is that aggregate industrial and commercial demands are the inverse of residential demands (i.e., Industrial/Commercial % = 100 – Residential %).

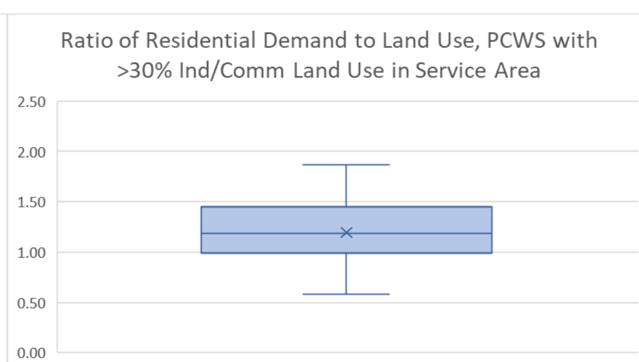
As with the prior analysis, service area land use percentages for residential, industrial and commercial land uses were drawn from the 2015 LULC coverage. Because the industrial and commercial demands are being addressed in aggregate, the land uses were likewise aggregated.

RESIDENTIAL

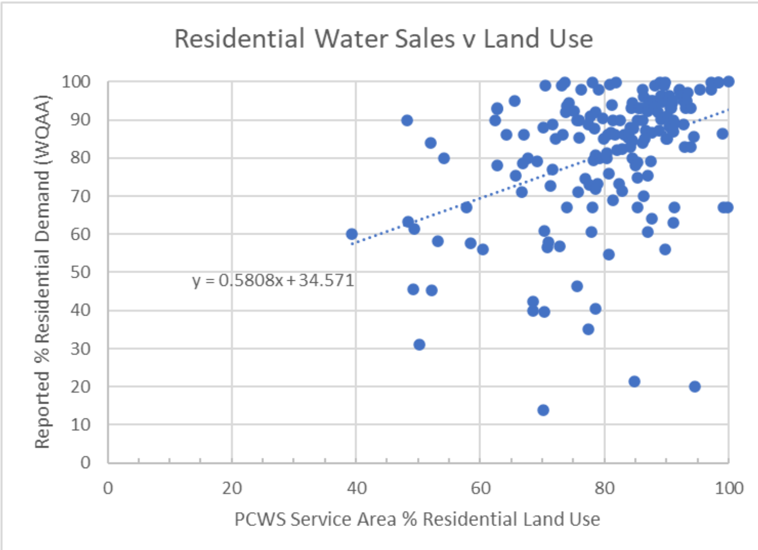
The first analysis focuses on the relationship of residential demands to residential land use, for PCWS with either 15% to 30% or greater than 30% industrial and commercial land use. The box and whisker plot for the 15% to 30% group indicates a tight relationship, with a median of 1.03 and a range from 0.92 to 1.17. The conclusion is that service areas with limited industrial and commercial land uses have a close relationship between residential demands and land uses. The second chart shows a greater range (0.99 to 1.45) and higher median (1.18), indicating that service areas with higher percentages of industrial and commercial demands have a less predictable relationship between residential demands and land uses; these areas are likely to be more urbanized and with high density residential areas, which have lower per capita residential water demands than is true for suburban areas (Van Abs et al., 2018).

The scattergram to the right shows the relationship between residential water sales and land uses for all PCWS in the data set. The pattern is far less linear than the results for the voluntary data discussed in the prior section, but still show a visual pattern correlating the two factors, with some significant outliers. For example, it is difficult to reconcile a service area of 100% residential land with a residential water demand of less than 80%, or a service area of 95% residential land with a residential water demand of 20%, which raises questions of whether the reported values represent a percentage of total sales (i.e., metered water at the customer level) or a percentage of total water delivered into the distribution system, which would include water losses and unmetered demands. Reporting errors are also possible, as this is the first year that these values were required under the WQAA reporting.





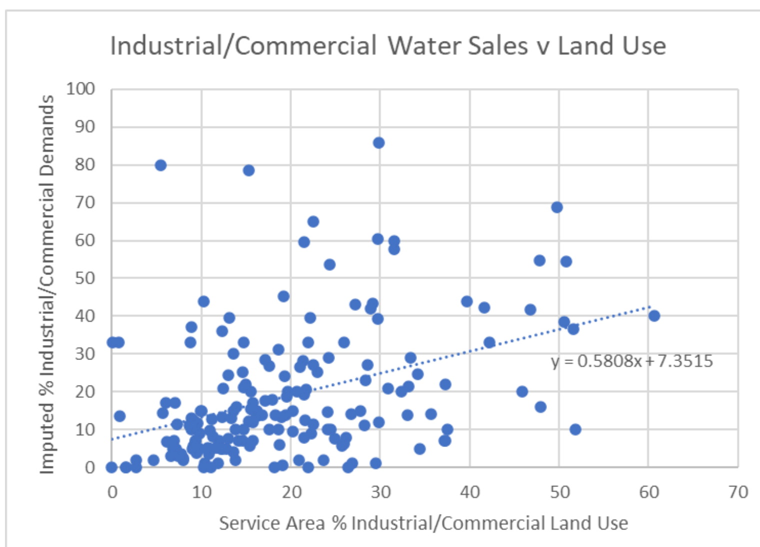
In comparison to the residential data based on PCWS volunteer data, the positive relationship between reported percent PCWS residential water sales and percent residential land use was much weaker, with a Pearson correlation coefficient of 0.398 (compared to the residential volunteer data's coefficient of 0.831). With the outliers removed, the Pearson correlation coefficient was slightly lower (0.327). However, this relationship both with and without outliers was found to be statistically significant with a p-value of less than 0.0001. The best fit line for this scattergram (outliers included) is y = 0.5808x + 34.571. With the outliers removed, the best fit line for this scattergram is y = 0.4104x + 51.333. The following equation is used to calculate residential (RES) demands from total demands:



RES Demand = (Total Demand – Water Loss) X (0.4104 (% RES Land Use) + 51.333) (Equation 1)

INDUSTRIAL AND COMMERCIAL

The following scattergram shows the relationship between aggregated water sales and land use by PCWS for these two sectors, which is essentially the inverse of the residential scattergram above. In this case, aggregating industrial and commercial demands and land uses provides a stronger correlation than the analysis of industrial demands alone using the voluntary data. For commercial demands, this chart is similar to the chart from the voluntary data, but with far more data points.



A **moderate positive relationship** was found between PCWS reported percent industrial and commercial water sales and percent industrial and commercial land use, with a Pearson correlation coefficient of 0.398 (0.327 with outliers removed). The relationship between industrial and commercial water sales and land use both with and without outliers was found to be statistically significant with a p-value of less than 0.0001. Based on this data's Pearson coefficient with outliers removed, the relationship between industrial and commercial water sales and land use is considered much weaker than the voluntary commercial water sales and land use data (0.557), but stronger than the total voluntary industrial water sales and land use

data (0.138). The best fit line for this scattergram (outliers included) is y = 0.5808x + 7.3515. However, with outliers removed, the best fit line for this scattergram is y = 0.4104x + 7.6249.

SELECTION OF RELATIONSHIPS BETWEEN DEMANDS AND LAND USES

Where a PCWS has provided RIC data voluntarily for this study, or residential percentages under WQAA where voluntary RIC data were not provided, the reported values will be used. The question is how to fill data gaps for PCWS without complete information.

The residential evaluation using the voluntary PCWS data provides a robust correlation between both residential and commercial demands and land uses, and it has sufficient data points (35) to support a linear relationship that can be used for PCWS lacking RIC or WQAA residential data, where industrial land uses are minimal (true of most small systems). For example, of those reporting residential data under the WQAA data, 78 of the 179 have less than 2% industrial land in their service areas.

However, the voluntary data have far fewer data points for industrial demands and the relationship between demands and land use is much weaker; many of the 35 PCWS have no or minimal industrial or commercial land uses, or both. That requires a reliance on the second analysis, even though the industrial/commercial aggregate demands are based on inverse of the residential percentages reported in the WQAA dataset and cannot be disaggregated. For this reason, analysis of existing and future demands for PCWS that lack RIC or residential data will be the portion of total demand that is not allocated to water losses or residential demands.

WATER DEMAND PROJECTIONS BY CUSTOMER SECTOR

Residential demand projections are affected by population, housing density and water conservation trends. Industrial demands are heavily dependent on industry type (e.g., warehousing versus food processing) and trends. Commercial demands (including retail and wholesale marketing, office buildings, and public buildings such as schools and governments) are affected by population trends and economic forces (e.g., shifts in purchasing practices from local stores or malls to big box stores to online shopping).

The 2050 PCWS water demands model addresses future demands differently for each sector.

- **Residential Demands**: Demand changes are based on population changes. For reductions, per capita demands will be those associated with the existing service area residential land use densities. For population increases, the per capita demands are assumed to be those associated with high density residential land uses (i.e., 5 units per acre or more), reflecting recent land development practices.
- **Commercial Demands**: Where current information exists on commercial demands, the projection assumes that these demands will change in proportion to population changes.
- **Industrial Demands**: Where current information exists on industrial demands, the projection assumes that these demands will remain static.
- **Industrial/Commercial Demands**: Where current information exists on aggregate industrial and commercial demands, the projection assumes that these demands will change in proportion to

population changes except for PCWS with high industrial land use percentages. In most cases, commercial demands will be the driving factor for PCWS service areas.

State of New Jersey
Department of Environmental Protection

2024 NEW JERSEY STATEWIDE WATER SUPPLY PLAN

APPENDIX G

SEASONAL PCWS DEMAND ANALYSIS: STATEWIDE AND COASTAL

SEASONAL PCWS DEMAND ANALYSIS: STATEWIDE AND COASTAL

Table of Contents

SEASONAL PCWS DEMAND ANALYSIS: STATEWIDE AND COASTAL

An analysis of the extent to which public community water systems (PCWS) in non-coastal, coastal, and barrier island coastal communities vary regarding the differences between summer and non-summer demands, expressed as the ratio between summer (June through September) and non-summer months. Coastal PCWS have much higher average ratios (2.37) than non-coastal PCWS. However, barrier island PCWS drive much of that difference. The relationship between the average ratio and the percentage of residential land use was strongest for barrier island PCWS and weakest for non-coastal PCWS.

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Statistical Analysis: Jillian Drabik, PhD
GIS Analysis: Chumba Koech, MCRP, Rutgers University-Bloustein School

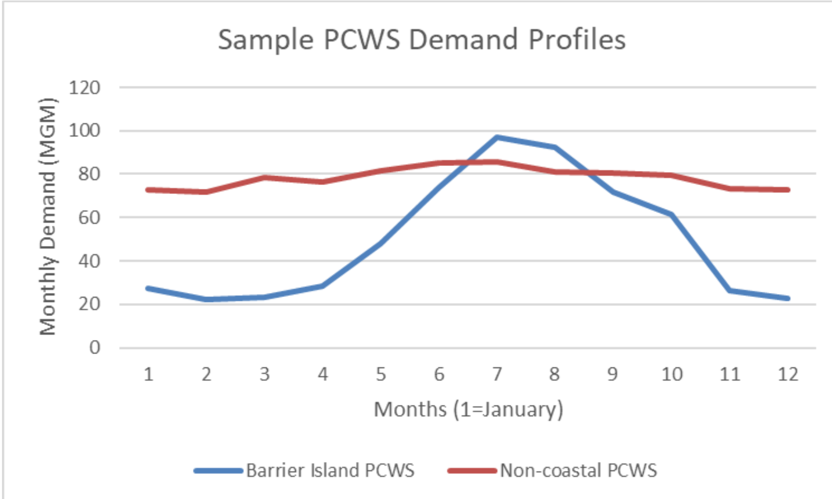
OVERVIEW OF ANALYSIS

Prior water demand analyses (Van Abs et al., 2018) showed that public community water systems (PCWS) with a significant exposure to the summer tourism economy had very different monthly demand patterns. While most PCWS have summer demands that exceed winter demands, this pattern was magnified for coastal PCWS along the Atlantic coast. For the 2024 NJSWSP, the analysis was further developed and with more detailed statistical tests, as reported in this appendix.

The first purpose of this analysis is to assess 5-year annual average demands and ratios of summer to non-summer demands for all PCWS that have available data, for use in the 2050 PCWS demands model. Monthly demand data for 464 PCWS were provided by DEP from the New Jersey Water Tracking database for this analysis. Summer months were selected as June through September, based on an analysis of aggregate monthly demands as a percentage of aggregate annual demands across all PCWS in the database.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
% of Annual Demands	7.7	7.0	7.5	7.4	8.3	9.4	10.5	10.0	9.3	8.5	7.2	7.4

The second purpose is to identify PCWS with ratios of summer to non-summer demands that are greatly higher than other PCWS, potentially reflecting a major coastal tourism demand, so that their demand projections should be assessed in a different manner than non-coastal PCWS. The distinction between PCWS demand profiles can be shown in the following chart for two PCWS; one is a barrier island PCWS and the other is a non-coastal PCWS in northern New Jersey. Summer demands slightly exceed non-summer demands for the non-coastal PCWS. However, summer demands are nearly five times the non-summer demands for the barrier island PCWS.



Analyses compared these ratios in several ways:

- statewide;
- by general geological area (Bedrock and Coastal Plain geology);
- by location on barrier islands and other near-coastal areas;
- by the percentage of the developed service area in Residential land uses; and
- by comparing the largest PCWS (comprising either 80% or 90% of total demands) to smaller PCWS.

SUMMARY OF RESULTS

The aggregate demands of all PCWS in the database represent nearly 1 billion gallons per day (997 mgd) in annual average demand for the years of 2016-2020. The ratio of summer to non-summer demands is 1.29, or roughly a 30% higher summer demand than the non-summer demand. The median value of individual PCWS results was 1.23, with a fairly wide distribution of values. The largest PCWS (80% of statewide demands, from 66 PCWS) have a ratio of 1.25 and a tighter distribution. Based on these results, a ratio higher than 2.0 was selected as representing an unusually high ratio.

The geological analysis provides a different perspective. PCWS serving areas with bedrock geology (which generally are not in major tourism areas) have an even lower ratio, of 1.19. Coastal plain PCWS, on the other hand, have a ratio of 1.49 and a wider distribution of values. The coastal plain PCWS can be further subdivided into those on Atlantic Coast barrier islands (primarily Ocean, Atlantic and Cape May counties), those with at least half of their service area within one mile of Atlantic Coast waters (either the shore or tidal bays), and those in the second set that are not on barrier islands. The results clearly indicate that barrier island PCWS have by far the highest median ratios. Interestingly, the non-barrier island coastal PCWS have a median that is not greatly different from the non-coastal systems.

	All Coastal PCWS (n=57)	Barrier Island PCWS (n=33)	Non-Barrier Island Coastal PCWS (n=24)	Non-Coastal PCWS (n=407)
Median Ratio of Summer to Non-Summer Demands	2.11	**3.17**	1.55	1.20

Statistical t-tests were conducted along with Mann-Whitney U tests (to address samples that may not have a normal distribution). These tests confirmed that coastal and non-coastal PCWS were significantly different, as were barrier island and non-barrier island coastal PCWS. Further, coastal PCWS in Monmouth County are statistically different from other coastal PCWS and from coastal PCWS.

The percentage of residential land use within the service area showed a lower correlation to the ratio of summer and non-summer demands for all sizes of PCWS, though coastal PCWS showed a somewhat stronger relationship than either barrier island or non-coastal PCWS. However, when PCWS size is added as a factor for either the ratios or % residential area by location (barrier island, coastal, non-coastal), some tests (barrier island PCWS and non-coastal PCWS for the ratio; % residential area for all locations) were found between the largest systems and all other systems in those locations. However, only two barrier island PCWS are within the top 80% PCWS, and seven with the top 90% PCWS.

The results show that barrier island PCWS have monthly demand profiles that are very different from profiles of non-coastal and even other coastal PCWS. Therefore, the projection of demands to the year 2050 will need to address these distinctions, as population changes will not have the same effects on annual demands as with other systems, due to the outsized tourism-based summer demands.

STATEWIDE ANALYSIS

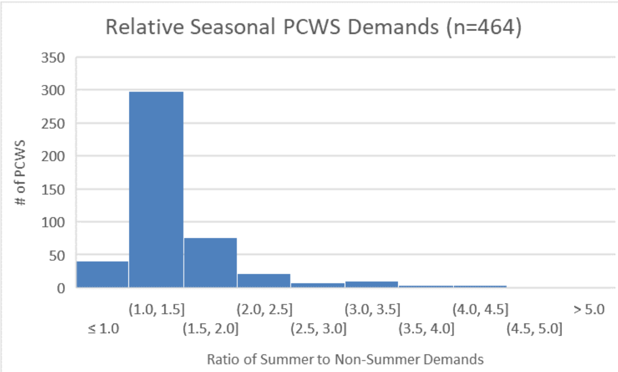
The primary focus of the statewide analysis is to understand the summer and non-summer withdrawals and the ratio between them. These values are important for two purposes. First, they are entered into the 2050 PCWS Demand Model directly for all PCWS for which data are available. Second, the results can be generalized for use in assessing summer and non-summer demands for PCWS that do not have available data.

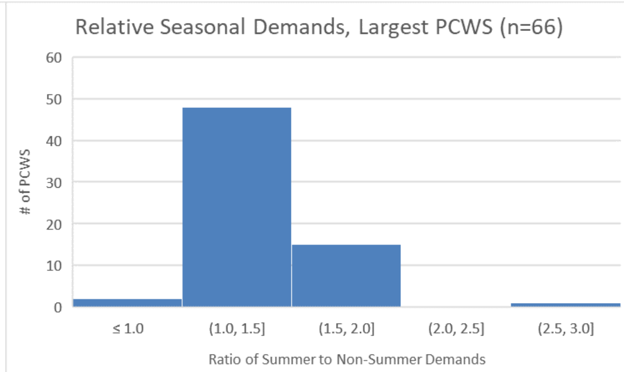
The statewide analysis involves 464 PCWS representing withdrawals as shown in the following table. Of the total annual average withdrawals, 66 PCWS represent 80% of all demands supplied to retail customers (i.e., not including regional wholesale systems such as the New Jersey Water Supply Authority and the North Jersey District Water Supply Commission, and accounting for bulk transfers among PCWS). The database includes some PCWS reporting that their ratio of summer to non-summer demands is less than one, which indicates that summer demands are less than non-summer demands, an unusual situation. These are included in the histograms and box plots below for completeness. Seven PCWS have values less than 0.8. Of these, six are very small systems or military facilities. One is a municipal system that has incomplete data. These seven PCWS are not included in the statistical tests section below.

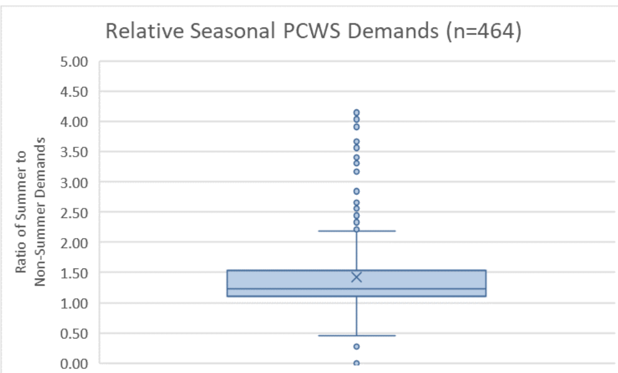
	Statewide Annual Average (mgd)	Statewide Summer Average (mgd)	Statewide Non-Summer Average (mgd)	Ratio of Summer to Non-Summer
TOTAL (n=464)	966.62	1138.95	885.97	1.29
Top 80% (n=66)	773.11	894.71	715.28	1.25

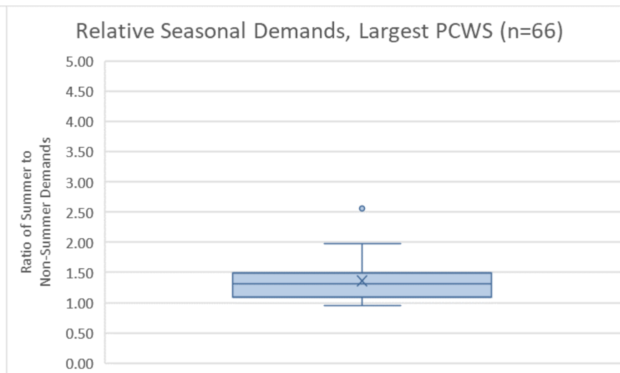
The analysis of summer to non-summer withdrawals is of primary importance in this study. Statewide, the ratio is 1.29, meaning that the statewide summer withdrawals are 29% higher than the statewide non-summer withdrawals. However, the median among all individual PCWS is lower, at 1.23. For the PCWS comprising 80% of all annual average demands, the ratio is 1.25. The following histograms and

box plots show the distributions. The box plots presenting the results with the median, 25th/75th percentiles, and outliers. The results for the largest 66 water withdrawals are markedly different, with a tighter range of ratios showing fewer results at the low and high ends.





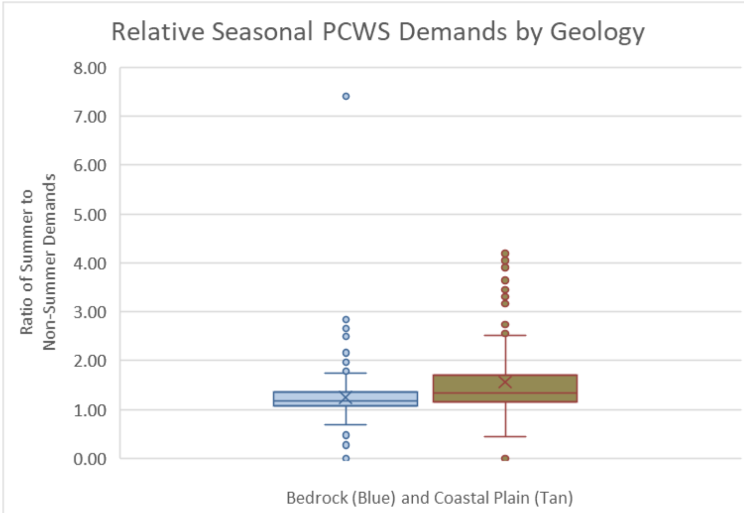




GEOLOGIC AREA ANALYSIS

One question is whether the ratios of summer to non-summer withdrawals differ significantly between PCWS located in bedrock geology and coastal plain geology. The following results indicate that the coastal plain PCWS have ratios that are markedly higher than for bedrock geology PCWS. Using total demands across all PCWS, the ratio is 1.19 for bedrock PCWS and 1.49 for coastal plain PCWS (25% higher). However, the median among all individual PCWS is lower, at 1.23 for bedrock PCWS and 1.34 for coastal plain PCWS (15% higher). As seen in the box plots, the results for bedrock systems are much tighter around the median that the results for coastal plain systems; the median coastal plain ratio (1.34) is essential the same as the 75th percentile result for bedrock PCWS (1.35).

	Statewide Annual Average (mgd)	Statewide Summer Average (mgd)	Statewide Non-Summer Average (mgd)	Ratio of Summer to Non-Summer
Bedrock (n=211)	633.15	711.77	598.32	1.19
Coastal Plain (n=253)	333.47	427.18	287.66	1.49

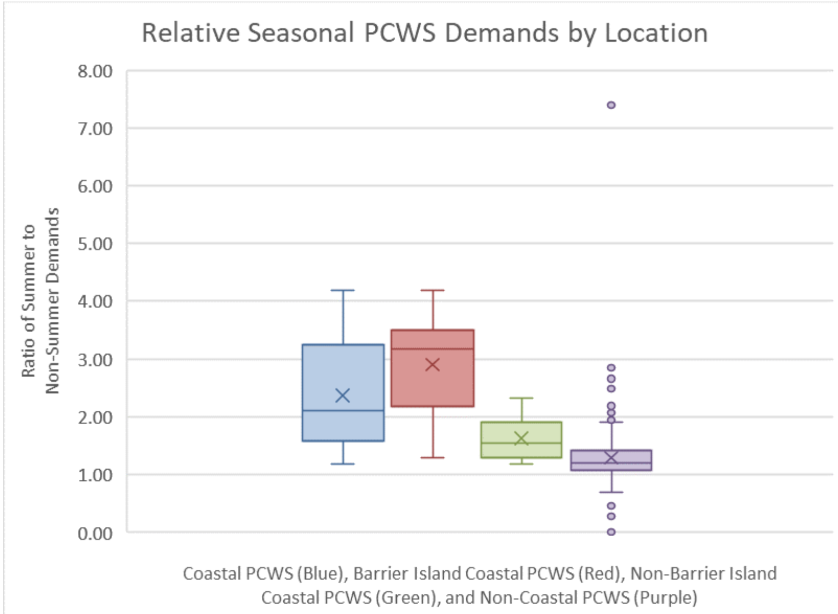


COASTAL SERVICE AREA ANALYSIS

A second question is whether the ratios of summer to non-summer demands differ significantly between PCWS that are on barrier islands or have significant service areas in close proximity to Atlantic coastal waters (i.e., the Jersey Shore or related bays. Barrier island PCWS are located on narrow areas of land that either extend from the mainland (e.g., Barnegat Peninsula) or are actually islands (e.g., Long Beach Island, Absecon Island). Coastal systems have greater than 50% of their service area within 1 mile of coastal waters, which by definition includes the Barrier Island PCWS. The results are as shown in the following table.

	Barrier Island PCWS (n=33)	All Coastal PCWS (n=57)	Non-Barrier Island Coastal PCWS (n=24)	Non-Coastal (n=407)
Median Ratio of Summer to Non-Summer Demands	**3.17**	2.11	1.55	1.20

The median ratio results indicate that Barrier Island and Coastal PCWS are very different (3.17 and 2.11, respectively). Excluding Barrier Island PCWS from the Coastal PCWS shows an even larger difference at 1.55, much closer to the non-coastal PCWW median of 1.20, indicating that the Barrier Island PCWS have much more prominent summer season peaks due to tourism than the other coastal PCWS. The box and whisker plot below shows the results in a different manner. Statistical tests bear this out, with significant differences between coastal and non-coastal PCWS and between barrier island and non-barrier island coastal PCWS.



STATISTICAL TESTS TO DETERMINE SIGNIFICANCE BETWEEN GROUPS

METHOD OVERVIEW

A series of statistical tests were conducted to detect significant differences in PCWS summer/non-summer demand ratios and % residential service areas across different PCWS characteristics. A table of findings from the t-tests and Mann-Whitney U tests is provided in the supplemental spreadsheet, while the findings of the correlation analysis are provided in-text. Several of the variables did not have a normal distribution, an assumption for t-tests that is especially important for conducting tests with small sample sizes (less than 20). For this reason, the t-tests were conducted along with Mann-Whitney U tests, a statistical test that does not assume samples have a normal distribution. For comparative purposes, the findings below provide the t-test findings along with those from the corresponding Mann-Whitney U Test. Greater confidence was placed in significant findings detected across both statistical tests. However, significant findings from only one test can warrant future analysis and may be the result of factors such as small or uneven sample size. All PCWS with summer/non-summer demand ratios less than 0.80 (n=7 and were very small PCWS) were excluded from statistical testing.

COAST AND NON-COASTAL PCWS

Regarding the Ratio of Summer to Non-Summer demands, are coastal PCWS statistically different from non-coastal PCWS? Within Coastal PCWS, is there a significant difference between Barrier Island and Non-Barrier Island Coastal PCWS?

A t-test was conducted to determine if coastal PCWS have significantly different summer/non-summer demand ratios than non-coastal PCWS. Coastal PCWS had an average ratio of 2.37, which was significantly higher (t=8.56; p=0.00) than the average ratio for non-coastal PCWS (1.30). The Mann-Whitney U Test comparing the demand ratios of these two groups supported this finding by concluding that non-coastal and coastal PCWS are distinct groups (U=20348; p=0.00).

A t-test was also conducted to determine if there is a significant difference in summer/non-summer demand ratios among barrier island coastal and other (i.e., non-barrier island) coastal PCWS. In order to conducting testing, the barrier island PCWS that are included in the coastal sample were removed to ensure the samples were independent from each other (referred to as non-barrier island coastal PCWS). Non-barrier island coastal systems had an average demand ratio of 1.63, which was found to be significantly lower (t=7.94; p=0.00) than the average ratio for barrier island PCWS (2.91). A Mann-Whitney U Test examining the demand ratios of these groups supported this finding by also concluding that there is enough statistical evidence to suggest that barrier island PCWS and non-barrier island coastal PCWS are distinct groups (U=724; p=0.00).

COASTAL PCWS SUBSETS

Are there subsets of coastal PCWS that are more like non-coastal PCWS?

There are subsets of coastal PCWS with demand ratios that are more like non-coastal PCWS. As shown in the results of the statistical testing comparing average summer/non-summer demand ratios of barrier island and non-barrier island coastal PCWS, the average ratio of non-barrier island coastal PCWS (1.63) was closer to the average ratio for non-coastal PCWS (1.30). However, statistical findings suggested that the difference in the average demand ratios of non-barrier island coastal and non-coastal PCWS was significant (t-test: t=4.37; p=0.00; Mann-Whitney: U=7614; p=0.00).

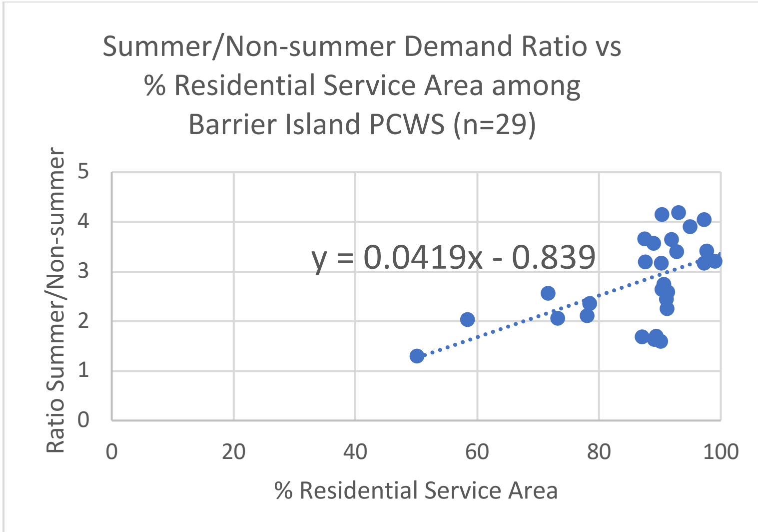
A second subset of coastal PCWS that are more like non-coastal PCWS was found in an analysis of summer/non-summer demand ratios among coastal PCWS based on county. A t-test was conducted to compare the average demand ratios of coastal PCWS in Monmouth County compared to the rest of the coastal sample. Coastal Monmouth PCWS were found to have an average demand ratio of 1.62, which was much lower than the average for the other coastal PCWS (2.57). The difference in the average ratios of coastal Monmouth and non-Monmouth PCWS was found to be statistically significant (t=-5.24; p=0.00). The Mann-Whitney U Test comparing demand ratios among coastal Monmouth PCWS and the rest of the coastal PCWS found that there was enough statistical evidence to conclude that the two groups were distinct (U=104; p=0.00). Therefore, we can conclude that coastal Monmouth PCWS appear to be a subset of coastal PCWS with demand ratios that are more similar to non-coastal PCWS. However, statistical findings suggested that the difference in demand ratio averages between coastal Monmouth and non-coastal PCWS was significant (t-test: t=2.74; p=0.02; Mann-Whitney: U=3667; p=0.00).

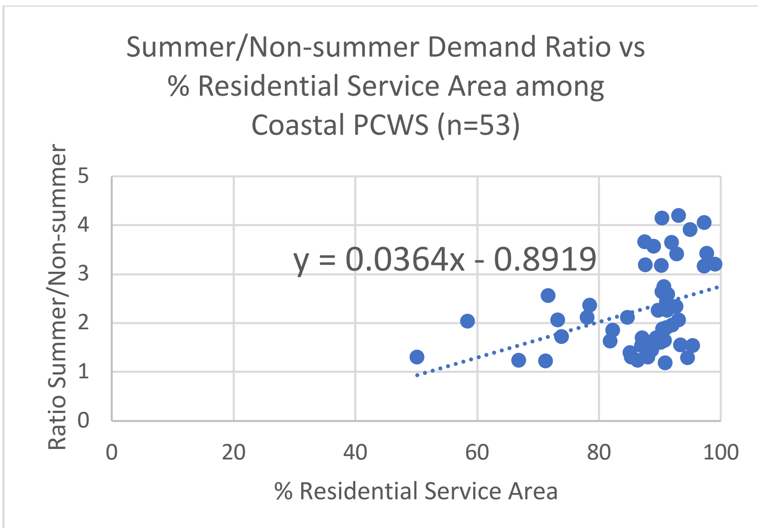
It should also be noted that all of the Monmouth PCWS are non-barrier island coastal PCWS. Although the significant findings here may only be a sub-finding of the larger sample non-barrier island PCWS findings discussed earlier in this section, further examination may determine if there are other characteristics specific to Monmouth County coastal PCWS that may result in smaller demand ratios than the other coastal PCWS.

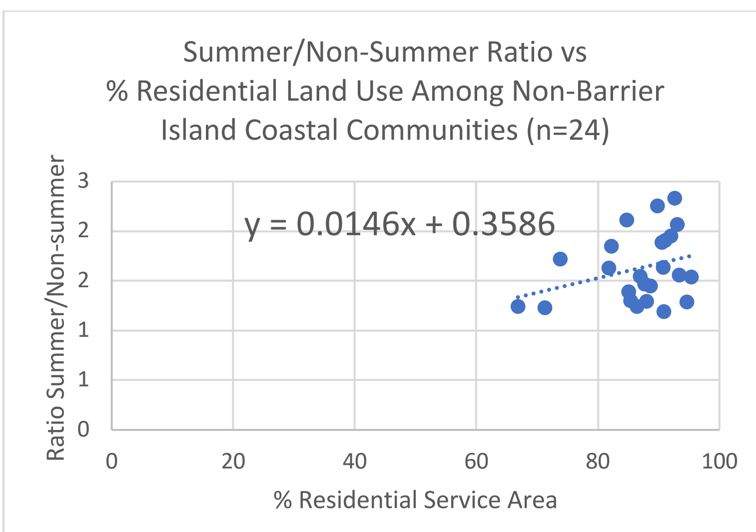
RELATIONSHIP OF DEMAND PROFILES TO RESIDENTIAL SERVICE AREAS

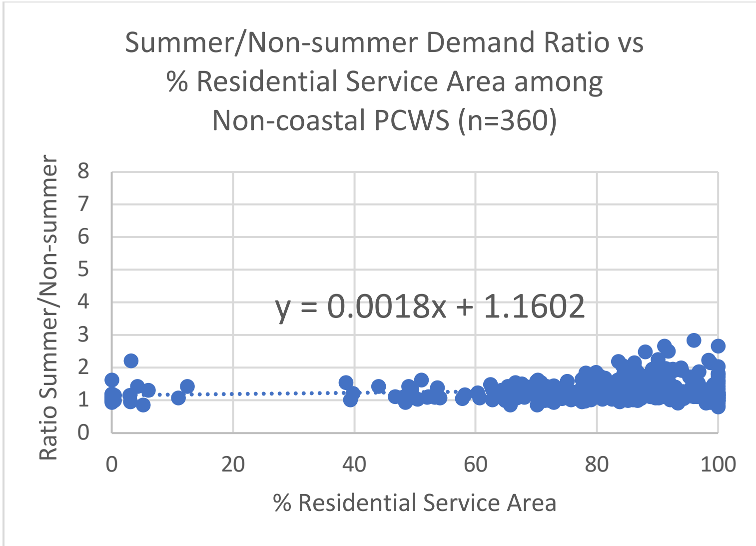
Does % Residential service area have a material effect?

To address this question, a correlation analysis was conducted alongside the t-tests and Mann-Whitney U tests. The scattergrams show summer/non-summer demand ratios and % residential service areas for PCWS in the following samples: barrier island, coastal (with and without barrier island PCWS), and non-coastal.


Summer/Non-summer Demand Ratio vs
% Residential Service Area among
Barrier Island PCWS (n=29)
y = 0.0419x - 0.839
Ratio Summer/Non-summer
% Residential Service Area
0
1
2
3
4
5
0
20
40
60
80
100


Summer/Non-summer Demand Ratio vs
% Residential Service Area among
Coastal PCWS (n=53)
y = 0.0364x - 0.8919
Ratio Summer/Non-summer
% Residential Service Area
0
1
2
3
4
5
0
20
40
60
80
100


Summer/Non-Summer Ratio vs
% Residential Land Use Among Non-Barrier
Island Coastal Communities (n=24)
y = 0.0146x + 0.3586
Ratio Summer/Non-summer
% Residential Service Area
0
1
1
2
2
3
0
20
40
60
80
100



For the barrier island PCWS (n=29), the Pearson Correlation Coefficient was 0.57 (indicating a moderate positive relationship between demand ratio and % residential service area), which was found to be significant (p=0.00). For the coastal PCWS (n=53), the Pearson Correlation Coefficient was 0.40, indicating a moderately positive, but weaker relationship between PCWS demand ratio and % residential service area compared to the barrier island sample. However, the relationship between these two variables was also found to be statistically significant (p=0.00). In comparison, the non-barrier island coastal PCWS (n=24) had a Pearson Correlation Coefficient of only 0.31, which was not found to be statistically significant (p=0.14). For the non-coastal PCWS (n=360), the Pearson Correlation Coefficient was 0.13, indicating a weak positive relationship between demand ratio and % residential service area, which was found to be significant (p=0.01). The significance test for the Pearson Correlation analysis determines if there is enough statistical evidence to conclude that the two variables (demand ratio and % residential service area) are associated with each other; it does not indicate strength of relationship. Therefore, we can conclude that there is statistical evidence to support that non-coastal PCWS demand ratio and % residential service area are associated with each other, although the Pearson Correlation Coefficient suggests that it is a weak relationship.

To investigate further, a series of t-tests and Mann Whitney U tests were conducted to examine if PCWS % residential service area was significantly different among barrier, coastal, and non-coastal PCWS with summer/non-summer demand ratios greater and less than two. It was not possible to run statistical tests on the non-barrier island coastal sample due to small sample size.

For the barrier island PCWS, PCWS with a demand ratio greater than two had an average % residential service area of 88.45%, which was larger than for the PCWS with a demand ratio less than two (81.17%). The difference in the averages of these two groups was not found to be significant (t=0.91; p=0.41). However, the Mann-Whitney U Test comparing the average % residential service area among barrier island PCWS with demand ratios greater and less than two provided marginal evidence to suggest that these two groups are distinct (U=91; p=0.08). However, the n for PCWS with a demand ratio less than two is only 5, a small sample size.

The t-test comparing the coastal PCWS sample found that PCWS with a demand ratio greater than two had an average % residential service area of 88.68%, which was slightly higher than the average for

PCWS with a demand ratio less than two (85.14%). In this case, the number of PCWS in the two groups was nearly equal (28 and 25, respectively). The difference in the averages between the two groups was not found to be significant (t=1.33; p=0.19). However, the Mann Whitney U Test comparing the average % residential service area of coastal PCWS with demand ratios greater and less than two did find enough statistical evidence to conclude that these two groups are distinct (U=463; p=0.04).

The t-test comparing the non-coastal PCWS sample revealed that PCWS with a demand ratio greater than two had an average % residential service area of 85.48%, which was larger than the average for PCWS with a demand ratio less than two (79.79%). In this case, the number of PCWS in the two groups was very different (13 and 347, respectively), emphasizing that a very small percentage of non-coastal PCWS have much higher summer demands (3.75%). The difference in the averages between the two groups was not found to be significant (t=0.79; p=0.44). The Mann-Whitney U Test comparing the average % residential service area of non-coastal PCWS with demand ratios greater and less than two found marginal statistical evidence to suggest that these two groups are distinct (U=2878; p=0.09).

Some statistical evidence was found to suggest that % residential service area has a material effect. The Correlation analysis provided evidence to conclude that PCWS % residential service area and summer/non-summer demand ratio are associated with each other in all three samples (barrier, coastal, and non-coastal). Some evidence of a material effect was also detected in the Mann-Whitney U tests, but not in the t-tests for the three PCWS samples. While Mann-Whitney U tests provide the benefit of being able to test differences among groups with small sample sizes and data with non-normal distributions, some strength of test findings is lost in tests with extremely unequal sample sizes (such as the non-coastal test). Further testing may provide further insight into if % residential service area has a material effect among all PCWS or if it has a material effect among sub-sets of the original three samples (there are some hints of this in the scattergrams, as it appeared that the demand ratio distributions get wider among the PCWS with larger % residential service areas across all three samples).

RELATIONSHIP OF DEMAND PROFILES TO PCWS SIZE

Does PCWS size have a material effect? In other words, do larger PCWS (comprising either 80% or 90% of statewide PCWS demands) show a stronger relationship of the Ratio to barrier island, coastal or % Residential metrics, or some combination?

EXAMINATION OF PCWS SUMMER/NON-SUMMER DEMAND RATIOS

To determine if PCWS size has a material effect, statistical testing was conducted to determine if PCWS comprising of either 80% (Top 80% Annual) or 90% (Top 90% Annual) of statewide PCWS annual average demands had significantly different summer/non-summer demand ratios for the following samples: barrier, coastal, and non-coastal. Due to sample size limitations, statistical testing for the 90% metric was conducted on all three samples, while statistical testing for the 80% metric was only conducted on the non-coastal PCWS sample. It was not possible to run any statistical tests on the non-barrier island coastal sample due to small sample sizes for Top 90% and Top 80% PCWS.

For the barrier island sample t-test, the Top 90% Annual PCWS (n=7) were found to have an average demand ratio of 2.30, which was lower than the other PCWS in the barrier island sample (3.07, n=26). The difference in the averages between these two groups was found to be statistically significant (t=-2.66; p=0.02). The Mann-Whitney Test examining average demand ratios among Top 90% and non-top

90% barrier island systems determined there was enough statistical evidence to conclude that these two groups are distinct (U=43; p=0.03).

For the coastal sample t-test, the Top 90% Annual PCWS (n=11) were found to have an average demand ratio of 1.98, which was lower than the other coastal PCWS (2.46, n=46). The difference in the averages between these two groups was found to be marginally significant (t= -1.95; p=0.07). The Mann-Whitney Test comparing the demand ratios among coastal Top 90 and non-Top 90 systems found that there was not enough statistical evidence to conclude that these two groups are distinct (U=182; p=0.16).

For the non-coastal sample t-test, the Top 90% Annual PCWS (n=109) were found to have an average demand ratio of 1.37, which was higher than the other non-coastal PCWS (1.29, n=290). The difference between the averages of these two groups was found to be not significant, but it was border-lining significance (t=1.49; p=0.14). The Mann-Whitney Test comparing the average demand ratios among non-coastal Top 90% and non-Top 90% systems found that there was enough statistical evidence to suggest that these two groups are distinct (U=18993; p=0.00).

For the second non-coastal sample t-test, the Top 80% Annual PCWS (n=63) were found to have an average demand ratio of 1.34, which was slightly larger than the average for other non-coastal PCWS (1.30, n=336). The difference in the averages between these two groups was not found to be significant (t=0.92; p=0.36). However, the Mann-Whitney U Test comparing the average demand ratios among non-coastal Top 80% and non-Top 80% systems found that there was marginal evidence to conclude that these two groups are distinct (U=12108; p=0.07).

The statistical test findings provide some evidence to suggest that PCWS size does have a material effect on PCWS demands ratio, although it appeared limited to barrier island PCWS. Although some marginal evidence was found in the coastal and non-coastal statistical tests, the barrier islands sample was the only sample to yield statistically significant findings across both tests. However, since there were also two tests in the coastal and non-coastal samples with results bordering marginal significance, further examination may help determine if a material effect also extends to these samples.

The statistical analyses do not address causation, but there is some potential that larger barrier island systems have a more diverse customer base, which could be tested by comparing percent residential demand (where a lower percentage would indicate more non-residential customers), or population density relative to residential area (where a lower value would indicate a higher concentration of rental units). Atlantic City is likely a special case, as it has a year-round tourism base (the casino industry) in addition to its summer tourism season, and therefore would have a different water demand profile. Its ratio of summer to non-summer demands is almost exactly the same as the statewide average for all PCWS.

EXAMINATION OF PCWS % RESIDENTIAL SERVICE AREA

A series of statistical tests were also conducted to examine if PCWS comprising of either Top 80% Annual or Top 90% Annual PCWS had significantly different % residential service areas for the following samples: barrier, coastal, and non-coastal. Due to sample size limitations, statistical testing for the 90% metric was conducted for all three samples, while statistical testing for the 80% metric was only conducted on the non-coastal PCWS sample. It was not possible to run any statistical tests on the non-barrier island coastal sample due to small sample sizes for Top 90% and Top 80% PCWS.

For the barrier island sample t-test, Top 90% PCWS (n=7) were found to have an average residential service area of 79.79%, which was lower than the other PCWS in the barrier island sample (89.56%, n=22). The difference in the averages of these two groups was not found to be significant (t=-1.63; p=0.14). The Mann-Whitney U Test comparing the average % residential service area among barrier island Top 90% PCWS and non-Top 90% PCWS determined there is enough statistical evidence to conclude that the two groups are distinct (U=38; p=0.05).

For the coastal sample t-test, Top 90% PCWS (n=11) were found to have an average residential service area of 81.37%, which was lower than the other PCWS in the coastal sample (88.49%, n=42). Although the difference in the averages of the two groups was bordering marginal significance, it was found to be not significant (t=-1.68; p=0.12). The Mann-Whitney U Test comparing the average % residential service area among coastal Top 90% and non-Top 90% PCWS found that there was marginal evidence to conclude that the two groups are distinct (U=150; p=0.08).

For the non-coastal sample t-test, Top 90% PCWS (n=106) were found to have an average residential service area of 75.65%, which was lower than the other PCWS in the non-coastal sample (81.81%, n=254). The difference in the averages of these two groups was found to be significant (t=-2.98; p=0.00). The Mann-Whitney U Test comparing the average % residential service area among non-coastal Top 90% and non-Top 90% PCWS supported the t-test finding. It found there was enough statistical evidence to conclude that the two groups are distinct (U=7493; p=0.00).

For the second non-coastal sample t-test, Top 80% PCWS (n=61) were found to have an average residential service area of 75.41%, which was lower than the other PCWS in the non-coastal island sample (80.93%, n=299). The difference in the averages between these two groups was found to be statistically significant (t=-2.66; p=0.01). The Mann-Whitney U Test comparing the average % residential service area of non-coastal Top 80% and non-Top 80% PCWS supported the t-test findings. It concluded that there was enough statistical evidence to conclude that the two groups are distinct (U=5462; p=0.00).

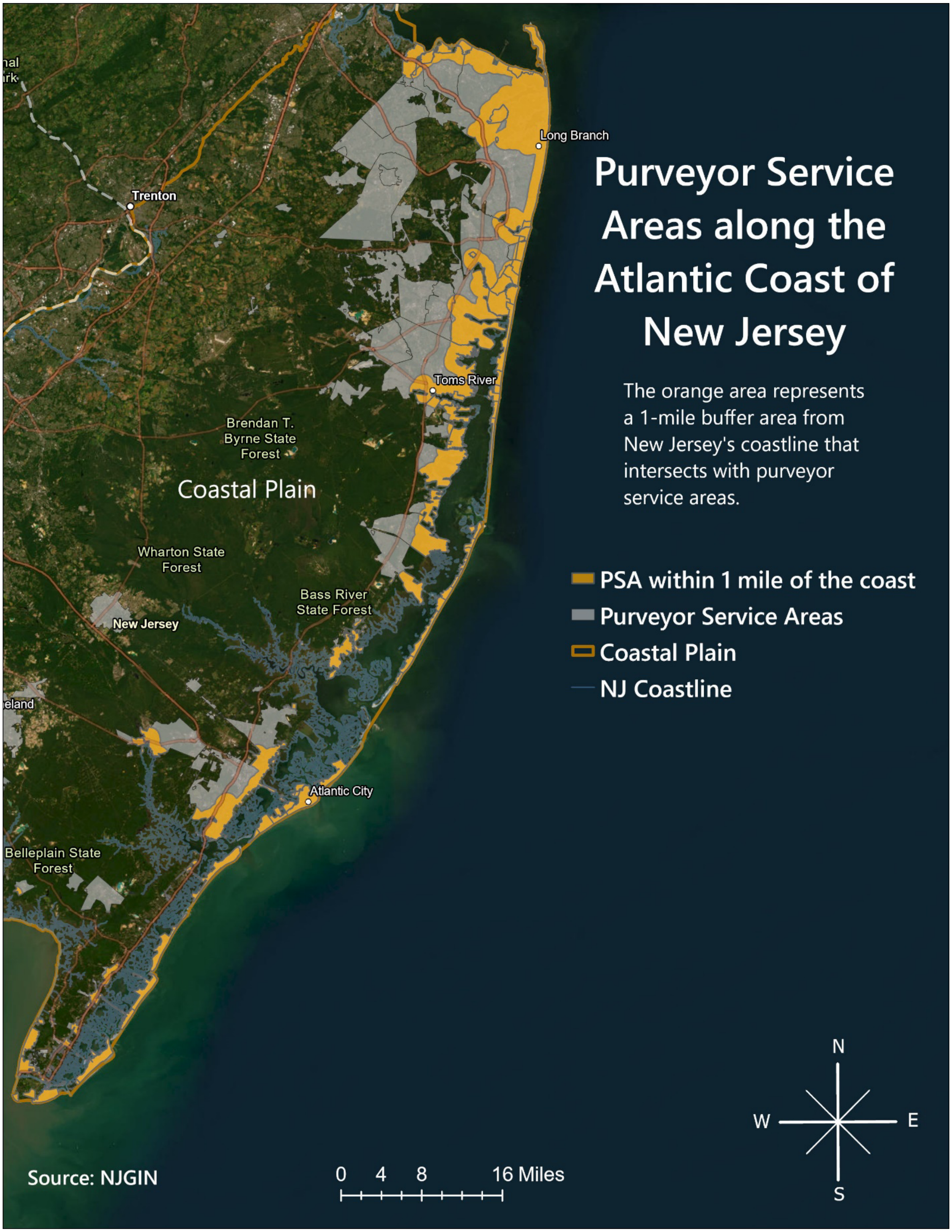
The statistical test findings provide some evidence to suggest that PCWS size does have a material effect on PCWS % residential service area. Statistically significant evidence was found in both the t-tests and Mann-Whitney U tests examining the non-coastal sample for both PCWS comprising of 80% and 90% of statewide PCWS demands. The findings for non-coastal PCWS are not surprising, given the large number of small PCWS that were created specifically for serving residential developments with little or no commercial presence and no industrial uses, such as mobile home (aka manufactured housing) parks and small, isolated subdivisions or apartment complexes. Large PCWS inevitably have a larger non-residential component. Although the t-tests for the barrier island and coastal samples were not found to be significant, they were bordering marginal significance. In addition, the Mann-Whitney U tests for these samples also suggested potential significance. Further examination with larger and possibly more even sample sizes may determine if a material effect extends to these PCWS as well.

APPENDIX A: GIS ANALYSIS

A GIS analysis based on DEP's Purveyor Service Areas of New Jersey was used to calculate the potential exposure of PCWS to seasonal shifts in demand from coastal tourism. The analysis identified the extent to which PCWS have a major component of their service area within 1 mile of a coastal shoreline (e.g., ocean, estuary or bay) along the Atlantic Coast (Monmouth, Ocean, Atlantic and Cape May Counties). The following approach was used:

- added the GIS layer of DEP Purveyor Service Areas;
- added the New Jersey GIN 2012 coastline layer;
- created a 1-mile buffer of the Atlantic coastal and back bay shorelines in Monmouth, Ocean, Atlantic and Cape May counties only;
- intersected Purveyor Service areas with the 1-mile buffer of coastal shoreline;
- created a table, with a column that calculated the area within the 1 mile buffer; and
- created a column for Coastal Service Area (%), which equals portion of the purveyor service area within the coastal shoreline 1 mile buffer divided by the total purveyor service area, by PWSID.

The following figure shows the relationship of service areas to the Atlantic Coast.


Purveyor Service Areas along the Atlantic Coast of New Jersey
The orange area represents a 1-mile buffer area from New Jersey's coastline that intersects with purveyor service areas.
PSA within 1 mile of the coast
Purveyor Service Areas
Coastal Plain
NJ Coastline
Long Branch
Trenton
Toms River
Brendan T. Byrne State Forest
Coastal Plain
Wharton State Forest
Bass River State Forest
New Jersey
Atlantic City
Belleplain State Forest
Source: NJGIN
0 4 8 16 Miles
N
W
E
S

APPENDIX B: SPREADSHEET DEVELOPMENT

This analysis uses data from the spreadsheet "NJWaTr_PWSID_Demands_2011-2020v3", which was loaded into a new spreadsheet, "NJWaTr_PWSID_Demands_2011-2020v3 Analysis". Information on the worksheets is provided below.

1. **Notation**: text documentation of the spreadsheet
2. **Annual All PCWS**: original data from DEP showing annual withdrawals, 2011-2020, in millions of gallons per year (mgy) by PCWS
    - Column P was added to provide an annual average for the years 2016-2020, in millions of gallons per day (mgd).
3. **Seasonal All PCWS**: This worksheet includes original data from DEP showing monthly average demands (mgm) for the years 2016-2020 by PCWS. The columns are included below.
    - A. SiteName: DEP designation of Drinking Water Use Area #
    - B. PermitNumber: Public Water Supply ID (PWSID) from DEP
    - C. CountyName: primary county location of the PCWS, from DEP
    - D. OwnerName: PCWS owner, from DEP
    - E. Through P: average monthly water demands for each month for 2016-2020, in mgm
    - Q. 2016-2020 Annual Avg (mgd): from Column P of **Annual All PCWS** table
    - R. 2016-2020 Summer Avg (mgd): average of values from Columns J through M (June through September)
    - S. 2016-2020 Non-Summer Avg (mgd): average of values from Columns E through I and N through P (all non-summer months)
    - T. Ratio Summer: Non-Summer: Column R divided by Column S
    - U. Ratio >2: indicates "Y" where Column T value is greater than the number 2, or "N" otherwise
    - V. Ratio <0.8: indicates "Y" where Column T value is less than the number 0.8, or "N" otherwise
    - W. IsBarrierDWSA: indicates "Y" where primary service area of PCWS is on a barrier island, or "N" otherwise
        - provided by DEP, with additions of three systems in the Long Beach Township system, Loveladies Harbor North and South and High Bar Harbor
    - X. CSA % (1=100%): indicates the fraction of a PCWS service area that is within 1 mile of coastal waters (Atlantic Ocean or related bays) in Monmouth, Ocean, Atlantic and Cape May counties (From Rutgers GIS analysis)
    - Y. Coastal Sort: indicates "Y" where either Column W is "Y" or Column X is greater than 0.5 (i.e., 50% coastal)

Z. RES% Served: fraction of the PCWS developed service area (i.e., excluding undeveloped areas such as wetlands, open space, barren lands) that is residential land use, from GIS analysis using the 2015 DEP Land Use/Land Cover data (From Van Abs et al. (2018) analysis)

AA. Geology (Coastal or Bedrock): indicates whether the primary portion of the PCWS service area is in Coastal (C) or Bedrock (BR) geology

AB. Top 90% Annual: indicates "Y" where a PCWS is among the largest annual demands that in aggregate comprise 90% of the statewide total demands provided by DEP

AC. Top 80% Annual: indicates "Y" where a PCWS is among the largest annual demands that in aggregate comprise 80% of the statewide total demands provided by DEP

- This is a subset of the PCWS in Column AB.

AD. Comments: provides information on data issue (e.g., months with no results) or the nature of a PCWS service area that may affect results (e.g., military facilities)

4. **Barrier Island Sort**: reorders the data from Worksheet 3 to identify those PCWS listed as Barrier Island PCWS, and then to segregate by the Ratio of summer to non-summer demands above and below 2; sorted in the following manner:
   - **IsBarrierDWSA (Column W)**;
   - **Ratio>2 (Column U)**; and
   - **PermitNumber (Column B)**.
5. **Atlantic Coast Sort**: reorders the data from Worksheet 3 to identify those PCWS listed as Coastal, and then to segregate by the Ratio of summer to non-summer demands above and below 2; sorted in the following manner:
   - **Coastal Sort (Column Y)**;
   - **Ratio>2 (Column U)**; and
   - **PermitNumber (Column B)**.
6. **Atlantic Coast Sort RES%**: reorders the data from Worksheet 3 to identify those PCWS listed as Coastal, allowing a comparison of the Ratio of summer to non-summer demands to the percentage of PCWS service area that is residential; sorted in the following manner:
   - **Coastal Sort (Column Y)**; and
   - **PermitNumber (Column B)**.
7. **Geology Sort**: reorders the data from Worksheet 3 to identify those PCWS in Coastal Plain (C) or Bedrock (BR) geology, allowing a comparison of the Ratio of summer to non-summer demands to geology of the PCWS service area; sorted in the following manner:
   - **Geology (Coastal or Bedrock) (Column AA)**;
   - **Top 90% Annual (Column AB)**;
   - **Ratio>2 (Column U)**; and
   - **PermitNumber (Column B)**.

APPENDIX C: STATISTICAL TESTS TABLE

Table: Statistical Tests Conducted to Examine PCWS Demand Ratios and % Residential Service Area						
PCWS Variable	**Testing Populations**	**Sample Size**	**Mean**	**Variance (t-test)/ Standard Deviation (Mann-Whitney U Test)**	**t-Score (t-tests) / U Statistic (Mann-Whitney U Test)**	**P-Value**
PCWS Demand Ratios by Location (Barrier, Coastal, Non-coastal)						
Summer/Non-summer Demand Ratio (t-test)	Coastal (all)	57	2.37	0.85	8.56	0.00**
	Non-coastal	399	1.30	0.21		
(Mann-Whitney U Test)	*Coastal (all)*	*57*	*2.37*	*0.92*	*20348*	*0.00***
	Non-coastal	*399*	*1.30*	*0.46*		
Summer/Non-summer Demand Ratio (t-test)	Barrier Island	33	2.91	0.69	7.94	0.00**
	Non-barrier Island Coastal	24	1.63	0.12		
(Mann-Whitney U Test)	*Barrier Island*	*33*	*2.91*	*0.83*	*724*	*0.00***
	Non-barrier Island Coastal	*24*	*1.63*	*0.35*		
Summer/Non-summer Demand Ratio (t-test)	Non-barrier Island Coastal	24	1.63	*0.12*	*4.37*	*0.00***
	Non-coastal	399	1.30	*0.21*		
(Mann-Whitney U Test)	*Non-barrier Island Coastal*	*24*	*1.63*	*0.35*	*7614*	*0.00***
	Non-coastal	*399*	*1.30*	*0.46*		
Summer/Non-summer Demand Ratio (t-test)	Coastal Monmouth	12	1.62	0.16	-5.24	0.00**
	Coastal Other	45	2.57	0.85		
(Mann-Whitney U Test)	*Coastal Monmouth*	*12*	*1.62*	*0.40*	*104*	*0.00***
	Coastal Other	*45*	*2.57*	*0.92*		
Summer/Non-summer Demand Ratio (t-test)	Coastal Monmouth	12	1.62	0.16	2.74	0.02**
	Non-coastal	399	1.30	0.21		
(Mann-Whitney U Test)	*Coastal Monmouth*	*12*	*1.62*	*0.40*	*3667*	*0.00***
	Non-coastal	*399*	*1.30*	*0.46*		

Table: Statistical Tests Conducted to Examine PCWS Demand Ratios and % Residential Service Area						
PCWS Variable	**Testing Populations**	**Sample Size**	**Mean**	**Variance (t-test)/ Standard Deviation (Mann-Whitney U Test)**	**t-Score (t-tests) / U Statistic (Mann-Whitney U Test)**	**P-Value**
PCWS Demand Ratios by % Residential Service Area - within Location Comparison (Barrier, Coastal, Non-coastal)						
% Residential Service Area (t-test: Barrier Island PCWS)	Demand Ratio Greater than 2	24	88.45	97.69	0.91	0.41
	Demand Ratio Less than 2	5	81.17	301.57		
(Mann-Whitney U Test)	*Demand Ratio Greater than 2*	*24*	*88.45*	*9.88*	*91*	*0.08**
	Demand Ratio Less than 2	*5*	*81.17*	*17.37*		
% Residential Service Area (t-test: Coastal PCWS)	Demand Ratio Greater than 2	28	88.68	85.20	1.33	0.19
	Demand Ratio Less than 2	25	85.14	101.22		
(Mann-Whitney U Test)	*Demand Ratio Greater than 2*	*28*	*88.68*	*9.23*	*463*	*0.04***
	Demand Ratio Less than 2	*25*	*85.14*	*10.06*		
% Residential Service Area (t-test: Non-coastal PCWS)	Demand Ratio Greater than 2	13	85.48	646.82	0.79	0.44
	Demand Ratio Less than 2	347	79.79	506.70		
(Mann-Whitney U Test)	*Demand Ratio Greater than 2*	*13*	*85.48*	*25.43*	*2878*	*0.09**
	Demand Ratio Less than 2	*347*	*79.79*	*22.51*		
PCWS Demands Ratio by 80% or 90% Cumulative PCWS Flows - within Location Comparison (Barrier, Coastal, Non-Coastal)						
Summer/Non-summer Demand Ratio (t-test: Barrier Island PCWS)	Top 90% Annual	7	2.30	0.41	-2.66	0.02**
	Non-top 90% Annual	26	3.07	0.66		
(Mann-Whitney U Test)	*Top 90% Annual*	*7*	*2.30*	*0.64*	*43*	*0.03***
	Non-top 90% Annual	*26*	*3.07*	*0.81*		
Summer/Non-summer Demand Ratio (t-test: Coastal PCWS)	Top 90% Annual	11	1.98	0.45	-1.95	0.07*
	Non-top 90% Annual	46	2.46	0.91		
(Mann-Whitney U Test)	*Top 90% Annual*	*11*	*1.98*	*0.67*	*182*	*0.16*
	Non-top 90% Annual	*46*	*2.46*	*0.96*		
Summer/Non-summer Demand Ratio (t-test: Non-coastal PCWS)	Top 90% Annual	109	1.37	0.07	1.49	0.14
	Non-top 90% Annual	290	1.29	0.26		
(Mann-Whitney U Test)	*Top 90% Annual*	*109*	*1.37*	*0.27*	*18993*	*0.00***
	Non-top 90% Annual	*290*	*1.29*	*0.51*		

Table: Statistical Tests Conducted to Examine PCWS Demand Ratios and % Residential Service Area						
PCWS Variable	**Testing Populations**	**Sample Size**	**Mean**	**Variance (t-test)/ Standard Deviation (Mann-Whitney U Test)**	**t-Score (t-tests) / U Statistic (Mann-Whitney U Test)**	**P-Value**
Summer/Non-summer Demand Ratio (t-test: Non-coastal PCWS)	Top 80% Annual	63	1.34	0.07	0.92	0.36
	Non-top 80% Annual	336	1.30	0.23		
(Mann-Whitney U Test)	*Top 80% Annual*	*63*	*1.34*	*0.27*	*12108*	*0.07**
	Non-top 80% Annual	*336*	*1.30*	*0.48*		
PCWS % Residential Service Area by 80% or 90% Cumulative PCWS Flows - within Location Comparison (Barrier, Coastal, Non-coastal)						
% Residential Service Area (t-test: Barrier Island PCWS)	Top 90% Annual	7	79.79	224.04	-1.63	0.14
	Non-top 90% Annual	22	89.56	86.74		
(Mann-Whitney U Test)	*Top 90% Annual*	*7*	*79.79*	*14.97*	*38*	*0.05***
	Non-top 90% Annual	*22*	*89.56*	*9.31*		
% Residential Service Area (t-test: Coastal PCWS)	Top 90% Annual	11	81.37	181.05	-1.68	0.12
	Non-top 90% Annual	42	88.49	64.48		
(Mann-Whitney U Test)	*Top 90% Annual*	*11*	*81.37*	*13.46*	*150*	*0.08**
	Non-top 90% Annual	*42*	*88.49*	*8.03*		
% Residential Service Area (t-test: Non-coastal PCWS)	Top 90% Annual	106	75.65	186.91	-2.98	0.00**
	Non-top 90% Annual	254	81.81	636.44		
(Mann-Whitney U Test)	*Top 90% Annual*	*106*	*75.65*	*13.67*	*7493*	*0.00***
	Non-top 90% Annual	*254*	*81.81*	*25.23*		
% Residential Service Area (t-test: Non-coastal PCWS)	Top 80% Annual	61	75.41	143.63	-2.66	0.01**
	Non-top 80% Annual	299	80.93	581.62		
(Mann-Whitney U Test)	*Top 80% Annual*	*61*	*75.41*	*11.98*	*5462*	*0.00***
	Non-top 80% Annual	*299*	*80.93*	*24.12*		
*implies significance at alpha=0.10						
**implies significance at alpha=0.05						

State of New Jersey
Department of Environmental Protection

2024 NEW JERSEY STATEWIDE WATER SUPPLY PLAN

APPENDIX H

AN ASSESSMENT OF REGIONAL WATER AVAILABILITY AND DEMAND FOR WATERSHED MANAGEMENT AREA (WMA) 06: UPPER AND MIDDLE PASSAIC, WHIPPANY, AND ROCKAWAY RIVERS

AN ASSESSMENT OF REGIONAL WATER AVAILABILITY AND DEMAND FOR WATERSHED MANAGEMENT AREA (WMA) 06: UPPER AND MIDDLE PASSAIC, WHIPPANY, AND ROCKAWAY RIVERS

Jillian R. Drabik, PhD, with Chumba Koech, MCRP, on GIS map preparation

August 2023

Table of Contents

EXECUTIVE SUMMARY

Watershed Management Area (WMA) 06 is located in northeastern New Jersey and includes most of Morris County and portions of Essex, Somerset, Sussex, and Union counties. The WMA includes four HUC11s (eleven-digit hydrologic units), which are the basis for water availability and demand accounting. Defined by its three major rivers (Upper Passaic, Rockaway, and Whippany), this region faces water supply vulnerability, with NJDEP estimates that 50% of the region has demonstrated water use patterns that exceed sustainable water availability during peak consumptive/depletive loss years. This report assesses water availability and demand for the region during the planning period (2020-2050) based on factors including regional population, social vulnerability, land use patterns, surface water and groundwater availability, demand, and quality, water utilities, and projected climate change impacts. A part of this analysis included a more focused examination of specific municipalities (Morristown, Parsippany-Troy Hills Township, Livingston Township, Millburn Township, New Providence Borough) identified as most likely to experience either significant growth or decline based on the population analysis; these are referred to as "focus municipalities".

Regional population analysis revealed that Sussex County was the only WMA06 county that experienced population decline between 2010 and 2020, and the population of WMA06's municipalities is projected to grow through 2050. Most WMA06 counties (Morris, Somerset, and Sussex) had unemployment rates and poverty levels below the New Jersey state average, though clusters of socially vulnerable populations in WMA06 were identified in locations including Dover, Victory Gardens Borough, Wharton Borough, Morristown, and Parsippany-Troy Hills Township. WMA06 water withdrawals have declined since the 1990s with predominant water withdrawals used for potable supply purposes, and water users have relied on a roughly even split of surface water and unconfined groundwater sources. While approximately half of WMA06's public community water systems (PCWSs) reported a decline in potable water demand between 2011-2020, WMA06 PCWS 2050 demand projections indicate that the majority of WMA06 PCWSs will experience less demand than current demand numbers. For the climate change assessment, Morris County was projected to have the largest increase in precipitation among WMA06 counties between 2020-2069. WMA06 was also projected to continue on-going trends of increased groundwater recharge and streamflow in the future, and they were projected to have little to no adverse impacts on regional surface water availability.

While vulnerability in current and/or future water availability was detected across three of four HUC11s in WMA06 (02030103010 (Passaic River Upr (above Pine Bk br), 02030103020 (Whippany River), and 02030103030 (Rockaway River)), several areas within WMA06's HUC11s were identified as particularly vulnerable.

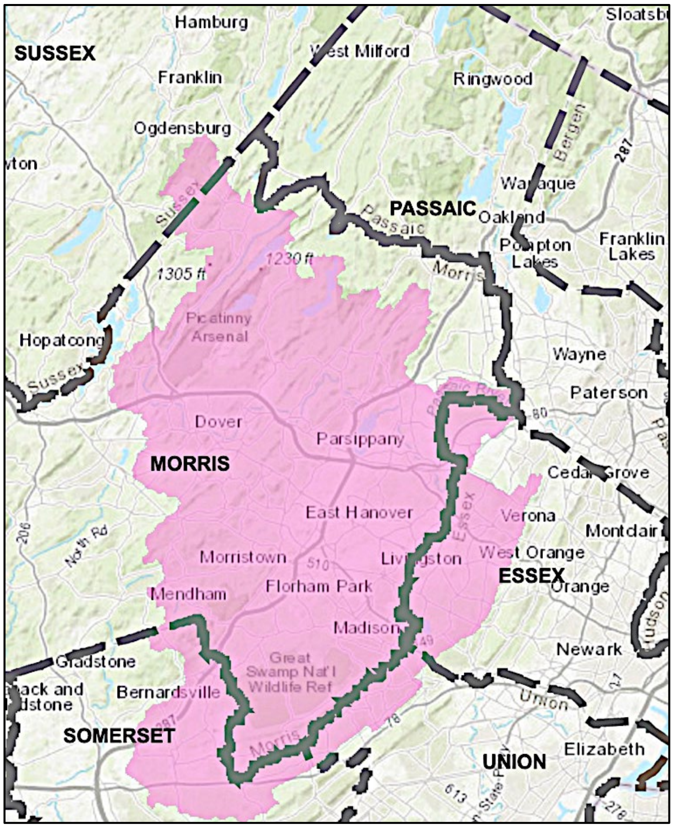
WMA06 Locations of Concern:

- Livingston Township, Millburn Township, and West Orange Township (HUC11: 02030103010)
- West Caldwell Township, North Caldwell Borough, and East Hanover Township (HUC11: 02030103010)
- Rockaway Township and Denville Township (HUC11: 02030103030)

Potential management options are provided that can be implemented across the WMA06 region or be more focused options for specific areas found to have the most significant water supply vulnerability. Management options included updating regional groundwater modeling, use of a water fee/surcharge on end users of Highlands water, protection of aquifer recharge areas, and further assessment of WMA06 PCWSs to meet future regional water demand.

1. INTRODUCTION

Watershed Management Area (WMA) 06 (see Map H1) is located in northeastern New Jersey and includes portions of Morris, Essex, Somerset, Sussex, and Union counties. The WMA06 region includes the upper and middle portions of the Passaic River and two major tributaries (Whippany River and Rockaway River), to where the Passaic River is joined by the Pompton River at Two Bridges (Highlands Council, 2008a). Encompassing a total area of 361 square miles, WMA06 is located in the Highlands and Piedmont physiographic provinces (NJDEP Division of Water Supply and Geoscience [forthcoming]; Town of Morristown Planning Division & Topology, 2020; Tetra Tech, 2020b). This region relies heavily on its groundwater sources for water supply and is characterized by extensive suburban development (Tetra Tech, 2020a).



Map H1. Map of WMA06

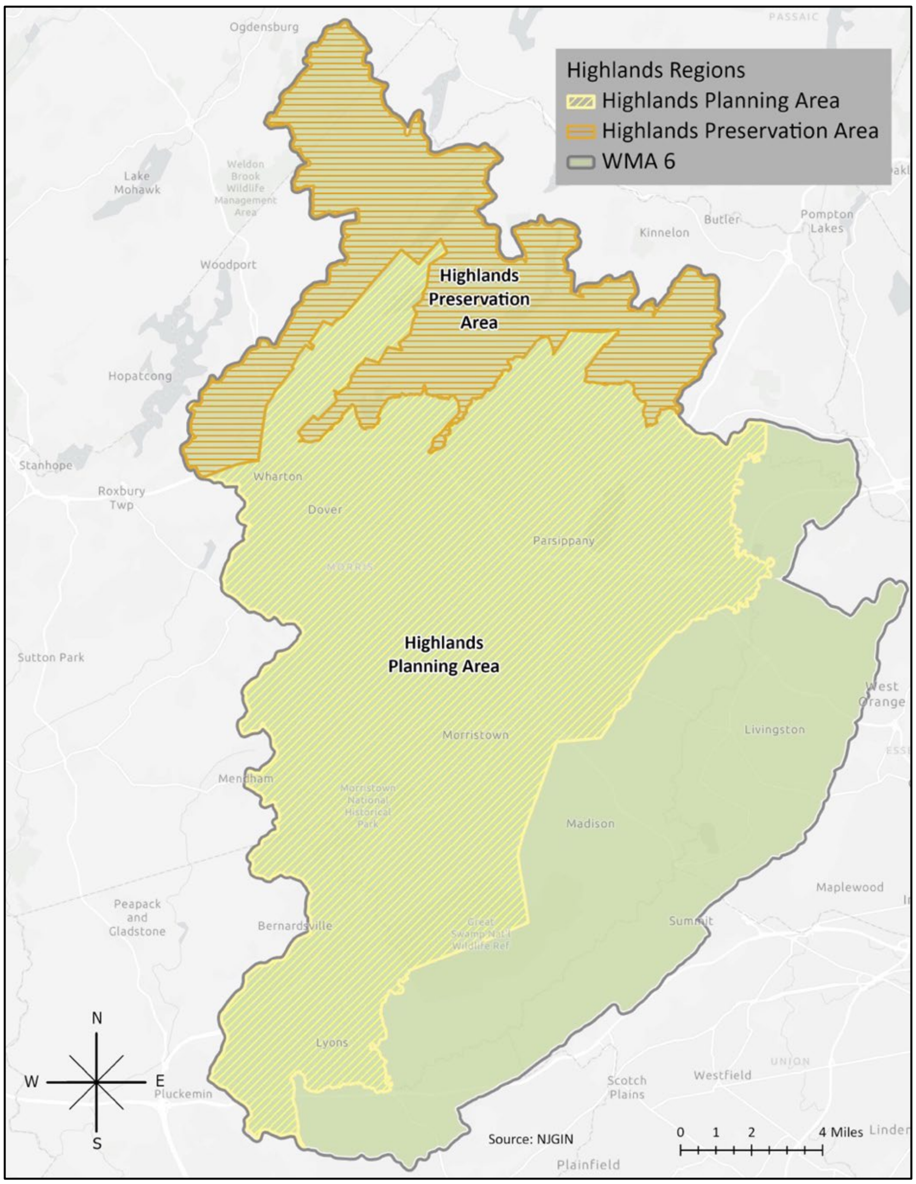
WMA06's land use and economic development is highly reliant on its regional surface water and groundwater sources. The three significant rivers in the region are the Rockaway, Whippany, and Passaic rivers, which are all watersheds within the larger Passaic River Basin (Morris County Planning Board, 2000). WMA06 encompasses the Upper Passaic River Basin, which includes its headwaters in Morris County to its confluence with the Pompton River. The Passaic River forms the boundary between Somerset and Morris counties and later between Morris and Essex counties. This basin drains approximately 987 miles of both North Jersey and Southern New York, including the Highlands Region (Tetra Tech, 2020a). The entire Passaic River Basin spans three WMAs: WMA03 (Pompton, Pequannock, Wanaque, and Ramapo), WMA06, and WMA04 (Lower Passaic and Saddle River).

Regulations for the Highlands Region (see Map H2) and the WMA's large wetlands areas (especially in the Passaic and Whippany river watersheds) present both land and water use restrictions that limit regional development and partially limit water demand. Including parts of seven New Jersey counties, the Highlands Region is a significant drinking water source for New Jersey residents that yields almost 380 million gallons of water daily (Morris County Planning Board, 2013; MCMUA, 2021). Regulations in the Highlands region, especially in the Preservation Area, include water withdrawal limits, new environmental standards, and restrictions on expanding public water and sewer service (Morris County Department of Public Works & Morris County Planning Board, 2018, Highlands Council, 2008b).

WMA06's primary groundwater sources are buried valley aquifer systems (Central Passaic Buried Valley Aquifer System and Upper Rockaway River Basin Area Aquifer System), partially developed from the expansion and retreat of glaciers during the Pleistocene Period which are now sole-source aquifers for

residents in portions of Morris and Essex counties (Morris County Planning Board, 2000; Morris County Planning Board & Morris County Office of Planning and Preservation, 2020; Amy S, Greene Environmental Consultants, Inc., 2014). These regional buried-valley aquifer systems have withdrawal restrictions, partially in response to earlier modeling research that identified concerns with withdrawal increases (Hoffman, 1989; Nicholson, McAuley, Barringer, & Gordon, 1996). In addition, the sole-source designation of these systems requires the Federal environmental review process to ensure funds are not provided for projects that risk contamination of the aquifer systems (Amy S, Greene Environmental Consultants, Inc., 2010).

With extensive regional development and New Jersey Department of Environmental Protection (NJDEP) estimates that 50% of WMA06's watersheds have demonstrated water use patterns during peak consumptive/depletive loss years that exceed sustainable surface water availability, examination of WMA06's current water availability and demand and how they may change in the future is critical for ensuring long-term adequate water availability for the region.



Map H2. Highlands Protection in WMA06

1.1 GOALS

This assessment is part of the larger 2024 New Jersey Statewide Water Supply Plan and provides a more detailed assessment of regional water availability and demand in WMA06 for the planning period (2020-2050). This regional evaluation is Step 3 of the Framework for Regional Water Supply Planning and Management that was outlined in the 2024 Plan. It has three main goals. The first goal is to identify current water availability and demand in WMA06. The second goal is to project how regional water availability and demand may change in the future. The third goal is to identify different potential management options that can be used to reduce regional water vulnerability and deficits.

2. METHODOLOGY

A multi-prong, multi-scale analysis was conducted to accomplish this assessment's goals. The four main components of this study (demographic analysis, water availability and demand analysis, climate change assessment, and development of potential management options) are described in the following sub-sections.

2.1 DEMOGRAPHIC ANALYSIS

The demographic analysis consisted of three sub-parts: population analysis (Section 4), social vulnerability assessment (Section 5), and current land use analysis (Section 6). The population analysis examined both economic and demographic characteristics of WMA06's counties and municipalities. Available population projections for WMA06's counties and municipalities for the study planning period (2020-2050) were examined to gather better insight into which locations are anticipated to significantly change in the future. Two population projection sources were considered for this analysis: (a) Metropolitan Planning Organization (MPO) (provided by the North Jersey Transportation Planning Authority (NJTPA)), and (b) New Jersey Department of Labor (DOL). MPO and DOL population projections were examined and compared with 2020 Census population estimates for WMA06's counties and municipalities to determine which locations are most likely to grow or decline in the future. Municipalities considered most likely to experience significant change in water demand due to population changes were selected for further analysis (referred to as focus municipalities).

The social vulnerability assessment focused on determining which WMA06 locations contained the most vulnerable populations. Social vulnerability was measured using two metrics, NJDEP's Overburdened Communities and the Center for Disease Control and Prevention's (CDC)'s 2018 Social Vulnerability Index (SVI). The identified vulnerable populations were considered throughout the latter sections of the study.

The current land use analysis focused on identifying current land use patterns, land development trends, and initiatives for preserving farmland and open space in WMA06. This analysis used both GIS and county and municipal documents to consider how WMA06 land use has changed over time and may change in the future. Development strategies suggested by WMA06 county planning boards, open space advisory committees, agricultural development boards, and economic improvement authorities were also used to consider future development trends and their impact on regional water demand.

2.2 WATER AVAILABILITY AND DEMAND ANALYSIS

The water availability and demand analysis focused on water quantity, water quality (both Section 7), and water utilities and infrastructure in WMA06 (Section 8). The water quantity section focused predominantly on data provided by NJDEP's Division of Water Supply and Geoscience (DWSG) to examine water withdrawal, discharge, and use patterns both regionally and on a smaller watershed scale (eleven-digit Hydrologic Unit Codes, or HUC11s). WMA06 water withdrawals were examined by both source and water use category, discharges (returns) were analyzed by source, and consumptive/depletive use was examined by water use category. Examination of WMA06's surface water vulnerability relied on the NJDEP's Low Flow Margin (LFM) method to determine which HUC11s are most stressed during their largest three-year rolling averages (peaks) of consumptive/depletive water loss. The water quality section examined surface water and groundwater sources using resources including NJDEP's 2018/2020 New Jersey Integrated Water Quality Assessment Report.

WMA06's water utilities and water infrastructure were examined using Public Community Water System (PCWS) data provided by NJDEP and county and municipal water infrastructure documents to assess

how regional water demand has changed over time. 2050 water demand projections for major PCWSs servicing WMA06 were also analyzed to examine their similarities and differences with the WMA06 2050 population projections discussed in Section 4 and their implications for assessing future regional water demand.

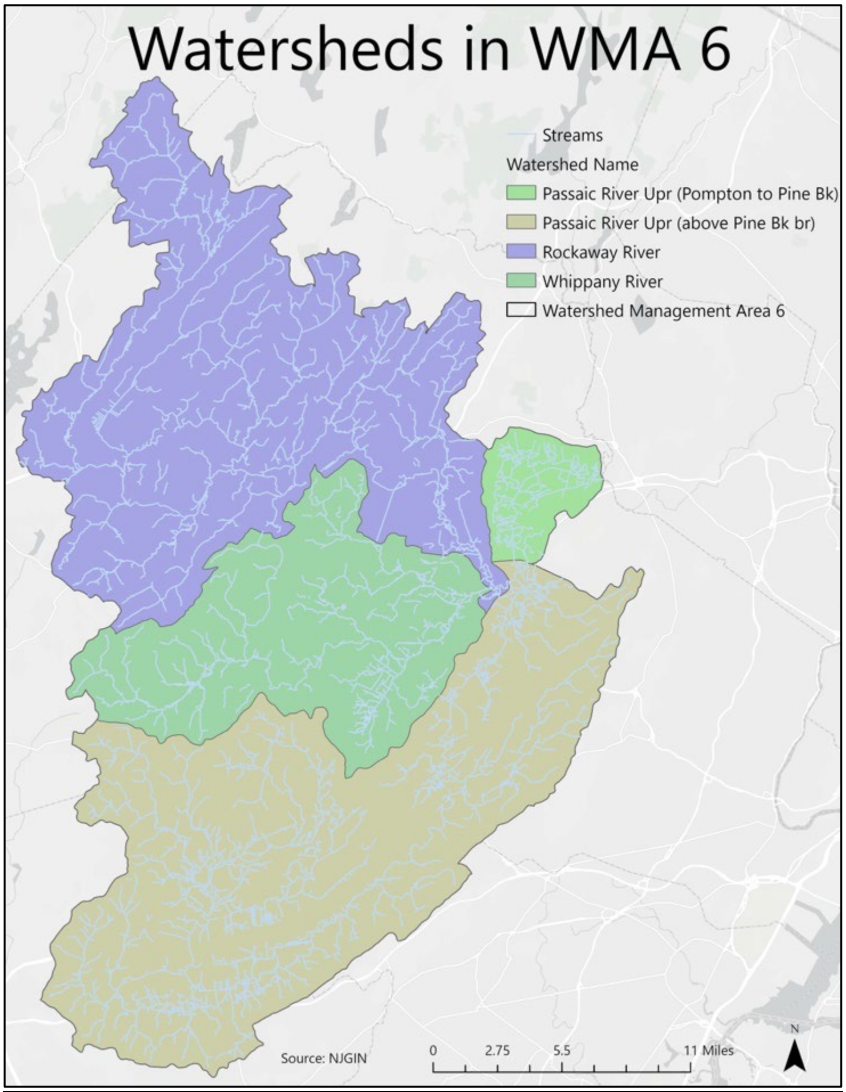
2.3 CLIMATE CHANGE ASSESSMENT

The climate change assessment (Section 9) primarily relied on data provided by NJDEP's DWSG to examine how climate change (temperature and precipitation) is projected to affect regional groundwater recharge, streamflow, and reservoir safe yields. For the examination of regional groundwater recharge, streamflow, and reservoir safe yields, forthcoming NJDEP reports were examined to identify current trends, and NJDEP projections were used to determine anticipated changes due to climate change.

2.4 DEVELOPMENT OF POTENTIAL MANAGEMENT OPTIONS

Based on the findings from the earlier sections, a list of potential management options was developed based on regional and more localized needs (see Section 10). Areas considered to have the highest water supply vulnerability in WMA06 were identified, and management options are proposed that are tailored to address both regional water issues and the specific needs/challenges identified in vulnerable locations.

3. WMA06 WATERBODIES



Map H3. HUC11 Drainage Basins in WMA06

Map H3 and Table H1 show all of the watersheds (or HUC11s) in WMA06. All four HUC11s are located entirely or partially in the Highlands Region and are subject to Highlands regulations (***All***: 02030103030; ***Partial***: 02030103010, 02030103020, 02030103040). All four HUC11s are considered 7Q10 Limited, meaning that the Low Flow Margin calculations (see Chapter 2 of the 2024 Plan) are further limited due to the potential for severe stream flow impacts during very dry periods. The 7Q10 (the lowest flows over a period of seven consecutive days with a 10 percent probability of occurrence) is a standard used in the 2017 New Jersey Statewide Water Supply Plan and Highlands water analyses (Highlands Council, 2008c).

HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	Highlands	7Q10 Limited	Municipalities
02030103010	Passaic River Upr (above Pine Bk br)	143	349	Partial	Yes	***Morris***: Montville Township, East Hanover Township, Morris Township, Mendham Township, Mendham Borough, Morristown, Florham Park Borough, Harding Township, Madison Borough, Chatham Township, Chatham Borough, Long Hill Township; ***Essex***: Fairfield Township, North Caldwell Borough, Caldwell Borough, West Caldwell Township, Verona Township, Cedar Grove Township, Roseland Borough, Essex Fells Township, West Orange Township, Livingston Township, Millburn Township; ***Somerset***: Bernardsville Borough, Bernards Township, Far Hills Borough, Warren Township, Bridgewater Township; ***Union***: Summit City, New Providence Borough, Berkeley Heights Township
02030103020	Whippany River	70	70	Partial	Yes	***Morris***: Boonton Township, Boonton Town, Denville Township, Mountain Lakes Borough, Parsippany-Troy Hills Township, Randolph Township, Morris Plains Borough, East Hanover Township, Hanover Township, Morris Township, Mendham Township, Mendham Borough, Morristown, Florham Park Borough, Harding Township, Madison Borough
02030103030	Rockaway River	137	206	All	Yes	***Morris***: Jefferson Township, Rockaway Township, Rockaway Borough, Kinnelon Borough, Boonton Township, Boonton Town, Montville Township, Mount Arlington Borough, Roxbury Township, Denville Township, Wharton Borough, Mountain Lakes Borough, Dover, Parsippany-Troy Hills Township, Mine Hill Township, Victory Gardens Borough, Randolph Township, East Hanover Township, Morris Township; ***Sussex:*** Hardyston Township, Sparta Township
02030103040	Passaic River Upr (Pompton to Pine Bk)	12	361	Partial	Yes	***Morris***: Montville Township, Lincoln Park Borough; ***Essex***: Fairfield Township

Table H1. HUC11 Information for Watershed Management Area 06
Data provided by NJDEP (Snook, Domber, & Hoffman, 2014; NJDEP Division of Water Supply and Geoscience (DWSG), 2021)

3.1 SURFACE WATER SOURCES

WMA06 is located in the Passaic River Basin and includes the Upper Passaic, Rockaway, and Whippany watersheds. The largest of these watersheds is the Upper Passaic River watershed, with the Whippany and Rockaway rivers as major watersheds that drain from the Highlands (Tetra Tech, 2020a; Highlands Council, 2008a). The Passaic River headwaters are in Mendham Township, from which the Passaic River flows through a total of 45 municipalities before ultimately emptying into Newark Bay. Within WMA06, the Passaic River flows through or adjacent to municipalities including Bernardsville Borough, Bernards Township, Long Hill Township, Chatham Township and Borough, Livingston Township, Hanover Township, Fairfield Township, and Montville Township. The Passaic River is joined by the Whippany River in Parsippany-Troy Hills Township and the Rockaway River in Pine Brook (Montville Township) (Morris County Planning Board, 2000; Tetra Tech, 2020a). Major tributaries within the Upper Passaic River include Dead River, Black Brook, Penns Brook, Cory's Brook, and Salt Brook. The Salt Brook branches join at the center of New Providence Borough before flowing into the Passaic River and are considered one of the defining features of the municipality (Somerset County Mitigation Planning Committee, 2019; Highlands Council, 2008a; New Providence Open Space Advisory Board, 2006). The Upper Passaic River floods in areas including Lincoln Park Borough, New Providence Borough, and Long Hill Township (Union County, 2016; Tetra Tech, 2020a; New Providence Open Space Advisory Board, 2006; Morris County Planning Board, 2000).

The Rockaway River's tributaries begin in eastern Sparta Township (Sussex County) and travel through Morris County (Tetra Tech, Inc., 2021; Morris County Planning Board, 2000). The Rockaway River flows in a southwesterly then easterly direction through Jefferson Township, Wharton Borough, Dover, Rockaway Borough, Denville Township, and Parsippany-Troy Hills Township, and flows to the Jersey City Reservoir at Boonton (Tetra Tech, 2020a; Morris County Planning Board, 2000; U.S. Army Corps of Engineers New York District & NJDEP, 2008). The Boonton Reservoir serves as a boundary that separates the Upper Rockaway River watershed from the Lower Rockaway River watershed (Gordon, 2002). Parsippany-Troy Hills Township is separated from Montville Township by the Rockaway River, which forms a natural municipal boundary line (Tetra Tech, 2020a). Major tributaries of the Rockaway River include Beaver Brook, Stone Brook, Den Brook, Mill Brook, Burnt Meadow, and Crooked Brook (Highlands Council, 2008a; U.S. Army Corps of Engineers New York District & NJDEP, 2008). The Rockaway River floods in areas including Parsippany-Troy Hills Township, Boonton Town, and Denville Township (Dewberry-Goodkind, Inc., 2006; Morris County Planning Board, 2000).

The Whippany River begins in Mendham Borough and travels in an easterly direction through Morris Township, Morristown, Hanover Township, East Hanover Township, and Parsippany-Troy Hills Township (Morris County Planning Board, 2000). In Hatfield Swamp, the Whippany River joins the Passaic River. The Whippany River is considered a major waterbody in Morristown and drains the northern section of the town (Tetra Tech, 2020a; Colliers Engineering & Design & Hipolit, 2021). Whippany River's watershed includes Intervale Lake, Troy Brook, Rainbow Lakes, Lake Parsippany, West Brook, and Black Brook (Dewberry-Goodkind, Inc., 2006; Highlands Council, 2008a). The Whippany River floods in several areas in WMA06, including East Hanover Township, Morristown, Morris Township, and Parsippany-Troy Hills Township (Tetra Tech, 2020a; Jonathan Rose Companies et al., 2014).

RESERVOIR SYSTEMS AND SAFE YIELD

There are two reservoir systems located in WMA06: (a) Jersey City's Boonton Reservoir System, and (b) New Jersey American Water Company's Passaic System (Canoe Brook), and both have permitted safe yields. Safe yield is defined as the amount of water a system can supply if there is a repeat of the worst drought on record (which is often the drought of the 1960s) (Highlands Council, 2008b). The Boonton

Reservoir System is owned by the City of Jersey City, and system operations have been contracted to Veolia. This system consists of two reservoirs: Splitrock and Boonton. Splitrock is located upstream of the Boonton Reservoir and can act as an emergency supply reservoir to the Boonton Reservoir during periods of low storage, drought, or other water supply emergencies. Located in Parsippany-Troy Hills Township, the Boonton Reservoir is considered the main reservoir and is Jersey City's direct source for potable supply (Highlands Council, 2008c; Burgis Associates, Inc., 2011). NJDEP reports this two-reservoir system has a combined storage of 11.3 bg and a safe yield of 56.8 mgd. As of 2008, both reservoirs had a passing flow requirement (5 mgd in Beaver Creek below Splitrock and 7 mgd in the Rockaway River below Boonton) (Highlands Council, 2008c). NJDEP estimates that average withdrawals from the Boonton Reservoir over the last five years were approximately 40 mgd, indicating that system water use was nearing the safe yield threshold, given that peak years will likely be higher.

The New Jersey American Water Company's Passaic System is designed to supply water to locations in northeast New Jersey (Highlands Council, 2008b). This system serves WMA06 locations including Berkeley Heights Township, Bernard Township, Bernardsville Borough, Far Hills Borough, Livingston Township, Millburn Township, New Providence Borough, Summit City, and Florham Park Borough. Municipalities serviced by New Jersey American's Passaic System can receive water from wells in unconfined aquifers and surface water from the Canoe Brook Reservoir System. The Passaic System's Canoe Brook Reservoir system includes three small reservoirs located in the Upper Passaic River Basin that are mainly fed by pumping from Canoe Brook and the Passaic River. NJDEP reports the combined storage of the three reservoirs is 2.84 bg, and the safe yield is 10.8 mgd.

3.2 GROUNDWATER SOURCES: BURIED VALLEY/VALLEY FILL AQUIFER SYSTEMS

The majority of groundwater in WMA06 is drawn from two sole source valley fill aquifer systems: (a) Central Passaic Buried Valley Aquifer System, and (b) Upper Rockaway River Basin Area Aquifer System. Sole Source Aquifers (SSAs) are designated by the U.S. Environmental Protection Agency under regulations provided in the Safe Drinking Water Act of 1974. This designation is provided when: (a) an aquifer system supplies over 50% of the drinking water for the aquifer service area, and (b) there are no economically feasible alternative drinking water sources (Hoffman, 1999; Highlands Council, 2008c; Amy S, Greene Environmental Consultants, Inc., 2014; Amy S, Greene Environmental Consultants, Inc., 2010; Burgis Associates, Inc., 2011). As a result of this designation, additional review of federally-funded projects is required to ensure Federal agencies don't commit funds to projects that risk contamination of these aquifer systems (Amy S, Greene Environmental Consultants, Inc., 2014; Amy S, Greene Environmental Consultants, Inc., 2010; Hoffman, 1999).

Both the Central Passaic Buried Valley and Upper Rockaway River Area aquifer systems have two different aquifer types that are separated by a partially confining unit, partially caused by the expansion and retreat of glaciers during the Pleistocene Period. The first aquifer unit consists of shallow unconfined, unconsolidated rocks in buried valley or valley fill deposits composed of gravel and/or sand, which is considered highly productive and a significant potable supply source in the region (although productivity may vary by location and rock type). These fluvial sand and gravel deposits filled bedrock depressions or river valleys during the retreat of glaciation. These buried valley aquifers are complex and interbedded with clay deposits. An aquifer of consolidated rocks (bedrock) exists throughout WMA06, including below the buried valley aquifers, but it is much less productive and is separated from the buried valley aquifers in some locations by a partially confining layer from glacial lake sediments or relatively tight sediments (Highlands Council, 2008c; Gordon, 2002; Hoffman, 2012; Morris County Planning Board, 2000; Burgis Associates, Inc., 2011). Groundwater and surface water are highly

interconnected in this area, as groundwater flows from higher elevations towards valleys, typically flowing from consolidated to unconsolidated deposits before discharging into streams, lakes, or swamps (Highlands Council, 2008c). However, surface water may also flow into the unconfined aquifers.

The Central Passaic Buried Valley Aquifer System is located in Somerset, Essex, Morris, and Union counties. Formerly known as the “Buried Valley aquifer in southeastern Morris and western Essex counties”, its notice of approval as an SSA was published in 1980 (Hoffman, 1999). Although it is mostly located in the Piedmont Province, its streamflow source zone extends into the Highlands (Highlands Council, 2008c). The recharge zone for this aquifer includes all of Morristown, Morris Plains Borough, Long Hill Township, Hanover Township, East Hanover Township, Madison Borough, and Florham Park Borough and parts of 19 WMA06 municipalities, and portions of the Passaic, Rockaway, and Whippany rivers all flow into this aquifer’s recharge zone (Hoffman, 1999). The Central Passaic Buried Valley Aquifer System is drained by the Passaic River, but during times of extended drought or heavy withdrawals, water can flow from the Passaic River to the aquifer (Highlands Council, 2008c).

The Upper Rockaway River Basin Area Aquifer System was formerly known as the “Unconsolidated Quaternary aquifer in the Rockaway River area, New Jersey” and its SSA notice of approval was published in 1984 (Hoffman, 1999). This aquifer system includes 13 Morris County municipalities that are located in the Rockaway River drainage basin upstream of the Boonton Reservoir. This area includes Boonton Town, Boonton Township, Randolph Township, Dover, Rockaway Township, Wharton Borough, and Roxbury Township (Morris County Planning Board, 2000; Highlands Council, 2008c). The Rockaway River Basin Area Aquifer System follows the ancient Rockaway River path and is currently an important streamflow source to the Rockaway River system (Morris County Planning Board, 2000; Burgis Associates, Inc., 2011; Highlands Council, 2008c). Along some areas of the Rockaway River, the river will lose water to the aquifer, but in other areas, the Rockaway River gains water from the aquifer. In the Rockaway River watershed, increased groundwater withdrawals upstream have been found to decrease groundwater discharge to the Rockaway River downstream, indicating the highly interconnected nature of the system (Gordon, 2002).

4. DEMOGRAPHIC ANALYSIS

KEY FINDINGS

- Overall, the population of WMA06 municipalities grew from 737,695 to 770,217 between 2010-2020. Among the WMA06 counties (Morris, Essex, Somerset, Sussex, and Union), only Sussex County experienced population decline between 2010-2020.
- While the projection analysis found MPO and DOL projections for WMA06 counties were similar in projecting growth in the WMA06 region, there was some uncertainty in the amount of population growth that would occur in WMA06's primary counties: Morris, Essex, and Somerset.
- Five WMA06 municipalities considered most likely to experience significant population changes (Morristown, Parsippany-Troy Hills Township, Livingston Township, Millburn Township, and New Providence Borough) were selected for further analysis in later sections of the regional assessment as focus municipalities.

4.1 POPULATION ANALYSIS AND INTRODUCTION TO FOCUS MUNICIPALITIES

The population analysis consisted of three components. The first two components assessed current demographic and population data for WMA06's counties and municipalities, respectively. The third component focused on the population projection analysis, which examined MPO and DOL county and municipality population projections for 2020-2050 and 2019-2034, respectively. Second and third component findings were used to identify the focus municipalities used in the later sections of the analysis.

COUNTY-WIDE ANALYSIS

Table H2 provides demographic information for WMA06's counties and includes state demographic information for comparative purposes. Essex County was found to have the largest population and population density among WMA06 counties; however, only the western-most part of the county is within WMA06, as is true for Union County. Essex, Union, Morris, and Somerset counties all increased in population between 2010-2020, while Sussex County was the only WMA06 county to experience population decline. However, as Sussex County's WMA06 municipalities make up less than 10% of WMA06's total acreage, Sussex County's population decline has a minimal impact on regional growth. Somerset County's growth in population continues an ongoing trend, as Somerset County experienced rapid population growth that was almost double the state growth rate between 2000-2010 (Somerset County Board of Chosen Freeholders, Somerset County Business Partnership, & CEDS Governing Committee, 2013); however, most of the more densely populated areas in the county are outside of WMA06. Despite Sussex experiencing recent population decline, Sussex, along with Morris, Somerset, and Union counties all grew prior to the Great Recession (Tetra Tech, Inc., 2021; Morris County Department of Public Works & Morris County Planning Board, 2018; Somerset County Board of Chosen Freeholders et al., 2013; Union County, 2016).

The economic conditions of WMA06's counties can be seen from examining WMA06 county data for unemployment rate, median household income, and percent poverty. Morris, Somerset, and Sussex were all found to have median household incomes that were above the New Jersey state average. This continues an ongoing trend of Morris and Somerset having some of the highest average incomes in New Jersey (Morris County Department of Public Works & Morris County Planning Board, 2018; Somerset County Board of Chosen Freeholders et al., 2013). Morris, Somerset, and Sussex counties were also found to have percent poverty and unemployment rates that were below the New Jersey state average.

While Union had median household income, percent poverty, and percent unemployment rates that were close to the New Jersey state average, Essex County reported significantly higher percent poverty and unemployment rates and a significantly lower median household income compared to the New Jersey state average. This suggests that Essex County is the most vulnerable out of WMA06's counties.

County	Essex	Morris	Somerset	Sussex	Union	New Jersey
Land Area (mi^2)	126	461	302	519	103	**7,353**
2020 Real GDP (Billions of Dollars)	$45	$49	$37	$4	$34	**$536**
2020 Population Density (per mi^2)	6,850	1,105	1,144	278	5,599	**1,263**
2010 Census	783,969	492,276	323,444	149,265	536,499	**8,791,894**
2020 Census	863,728	509,285	345,361	144,221	575,345	**9,288,994**
Median Household Income	$63,959	$122,962	$124,764	$99,904	$86,764	**$89,296**
Percent Poverty	15%	6%	5%	6%	9%	**10%**
Unemployment Rate (May 2021 - not seasonally adjusted)	4%	3%	3%	3%	4%	**3%**

Table H2. WMA06 County Demographic Information
Sources: 2020 U.S. Census (U.S. Census Bureau, 2021), 2020 ACS 5-year estimate (American Community Survey, 2022a), Bureau of Economic Analysis (2021), NJ Department of Labor and Workforce Development (2022), 2021 ACS 1-year estimate (American Community Survey, 2022b)

Several WMA06 counties have developed regional strategies for promoting economic development in WMA06. Morris County has focused on building sector growth in areas including: (a) Healthcare and Social Assistance; (b) Professional, Scientific, and Technical Assistance; and (c) Administrative Support/Waste Management/and Remediation (Morris County Planning Board, 2013). Somerset County was interested in job creation and receiving economic investment from the private sector, and was projecting sector growth in Wholesale Trade, Retail Trade, and Professional, Scientific, and Technical Services (Somerset County Board of Chosen Freeholders et al., 2013). As a part of their strategic development plan, Sussex County was interested in: (a) expanding their tourism and hospitality industry; (b) improving roadways and transit; (c) coordinating with NJDEP to accommodate targeted growth with municipality partnerships; and (d) supporting agriculture businesses by partnering with New Jersey Department of Agriculture (Econsult Solutions Team, 2014).

MUNICIPALITY ANALYSIS

WMA06 includes municipalities in most of Morris County, western Essex County, northern Somerset (Bernards Township, Bernardsville Borough, Far Hills Borough, Warren Township), southeastern Sussex (Hardyston Township, Sparta Township), and western Union County (Berkeley Heights Township, New Providence Borough, Summit City). Similar to the county-level analysis findings, most of WMA06's municipalities grew between 2010-2020, with both Sussex County municipalities experiencing population decline during this time. Twenty-six of 31 Morris County municipalities within WMA06 reported population growth between 2010-2020 (only East Hanover Township, Jefferson Township, Kinnelon Borough, Long Hill Township, and Roxbury Township reported declines), while all of Essex, Somerset, and Union's WMA06 municipalities reported growth. The average percent population growth of WMA06's municipalities between 2010-2020 was 4.7% (U.S. Census Bureau, 2021).

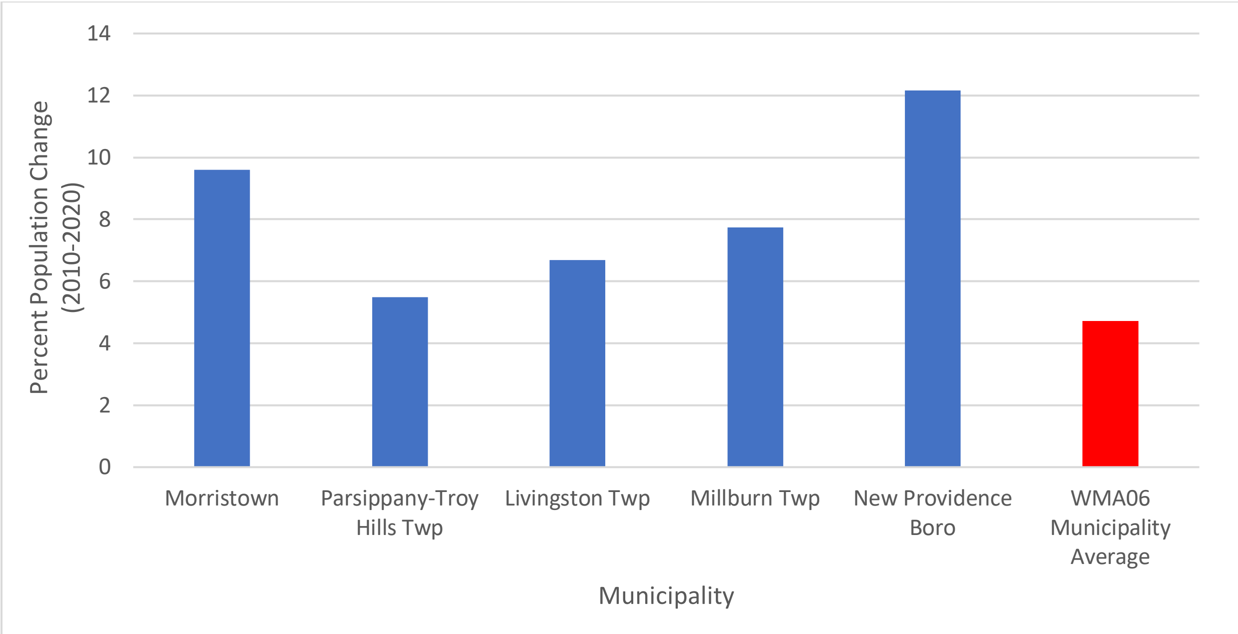


Figure H1. Percent Population Change in WMA06 Municipalities (2010-2020)

Figure H1 shows the percent population change experienced by the WMA06 municipalities selected as focus municipalities, as compared to the average percent population change of all of the WMA06 municipalities (not of WMA06's total population). Focus municipalities are municipalities identified as most likely to experience significant population changes (growth or decline) and potentially water demand changes in the future. Identification of focus municipalities was based on factors including municipal percent population changes between 2010-2020, examination of county planning documents, 2020 percent difference between municipal MPO projection and census population (discussed in the next sub-section), and MPO projected municipal growth through 2050 (discussed in the next sub-section).

As shown in Figure H1, all of the focus municipalities selected for analysis demonstrated growth between 2010-2020 that exceeded the WMA06 municipality average. While New Providence Borough (which is partially located outside of WMA06) had the largest percent growth (12.2%) among the focus municipalities between 2010-2020, Parsippany-Troy Hills Township experienced the largest total population growth between 2010-2020, growing by 2,924 people. Morristown experienced the second largest percent population change among the focus municipalities (9.6%). Livingston Township and Millburn Township experienced smaller population growth between 2010-2020 (growing by 1,964 and 1,561 people, respectively) (U.S. Census Bureau, 2021).

POPULATION PROJECTION ANALYSIS

Figure H2 shows the MPO and DOL population projections (estimates) for the five WMA06 counties. Both the MPO and DOL population projections were developed prior to the 2020 Census and therefore are based on the 2010 Census data and subsequent annual estimates. The 2020 Census results show significant differences from the earlier modeled results.

With the exception of Sussex County, all WMA06 counties had 2020 Census populations that exceeded their MPO 2020 projections. All WMA06 counties had 2020 Census populations that exceeded their DOL 2020 projections. MPO and DOL projections for WMA06 counties significantly differ in both projected growth estimates and projections of which counties would experience the most growth. For example,

for Morris County, the MPO projected a population increase of 13,023 people between 2020-2035, while the DOL projected a population increase of 38,900 people between 2019-2034. Somerset was similar, with the MPO projecting a population increase of 17,290 people between 2020-2035, and the DOL projecting a population increase of 35,800 people between 2019-2034. For both Morris and Somerset counties, their 2020 Census population numbers were closer to their DOL 2019 projections than their MPO 2020 projections (compare 509,285 with 509,100 and 500,829, and 345,361 with 342,900 and 336,521, respectively) (NJTPA, 2021; DOL, 2014; U.S. Census Bureau, 2021).

Essex County was similar (but in the opposite direction) in that the MPO projected a population increase of 56,472 people between 2020-2035, while the DOL projected growth of 31,800 people between 2019-2034. In comparison, Essex County's 2020 Census population was much higher than both the county MPO 2020 and DOL 2019 projections (compare 863,728 to 800,276 and 808,300 respectively), creating some uncertainty in how much growth Essex County will experience in the future.

As of 2020, Morris County WMA06 municipalities were approximately 55% of the WMA06 total municipal population, followed by Essex (22%) and Somerset (13%) counties. Since the WMA06 municipalities from these three counties make up approximately 90% of WMA06's total municipal population, the projection findings for Morris County, along with Essex and Somerset counties, suggest some uncertainty in how regional population (and potentially water demand) may change in the future (NJTPA, 2021; DOL, 2014; U.S. Census Bureau, 2021).

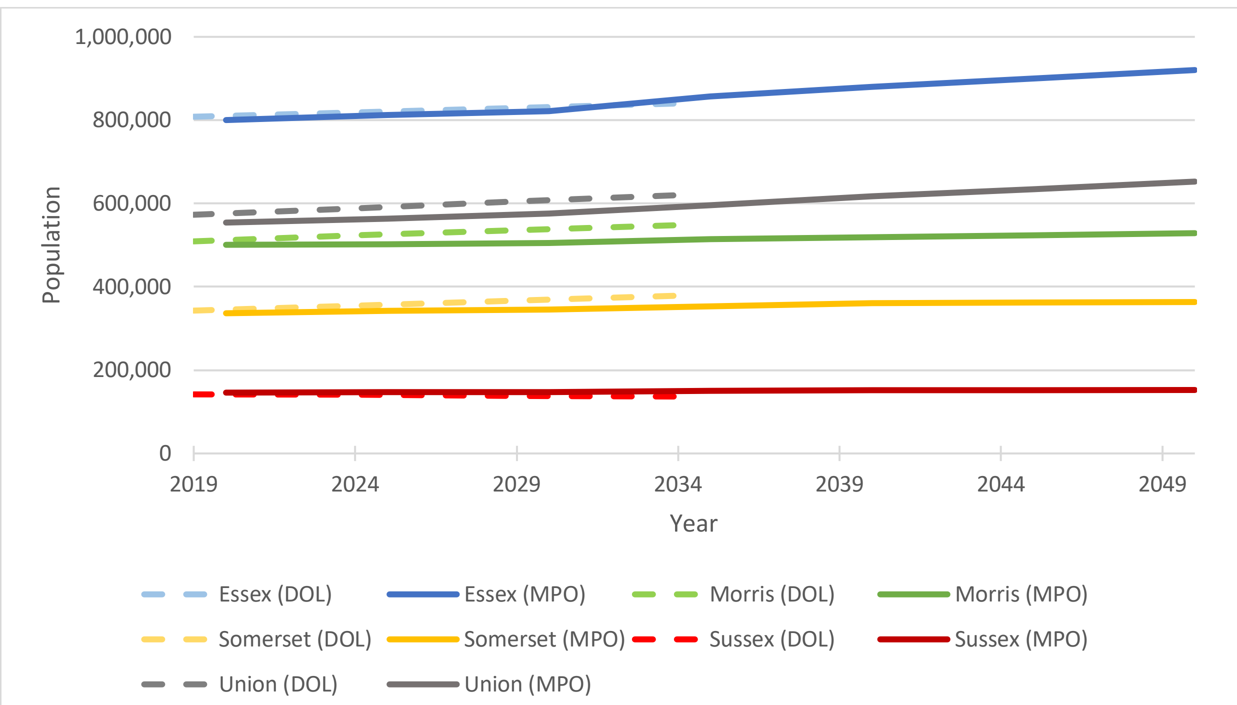


Figure H2. MPO and DOL Population Projections for WMA06 Counties (2019-2050)

Figure H3a and b demonstrate how the WMA06 focus municipalities were selected for analysis. All of the focus municipalities had 2020 Census populations that exceeded their MPO population projections. In Essex County, population data suggested a potential cluster of future population growth in the adjacent Livingston Township, Millburn Township, and West Orange Township. All three of these municipalities were projected by the MPO to have growth that significantly exceeds the WMA06 municipality average, with West Orange Township projected to have the most significant growth (7,236 person increase between 2020-2050). While both Livingston Township and Millburn Township were

selected as focus municipalities, West Orange Township was not since it is primarily located outside WMA06 (primarily located in WMA07 – Arthur Kill) (NJTPA, 2021; DOL, 2014).

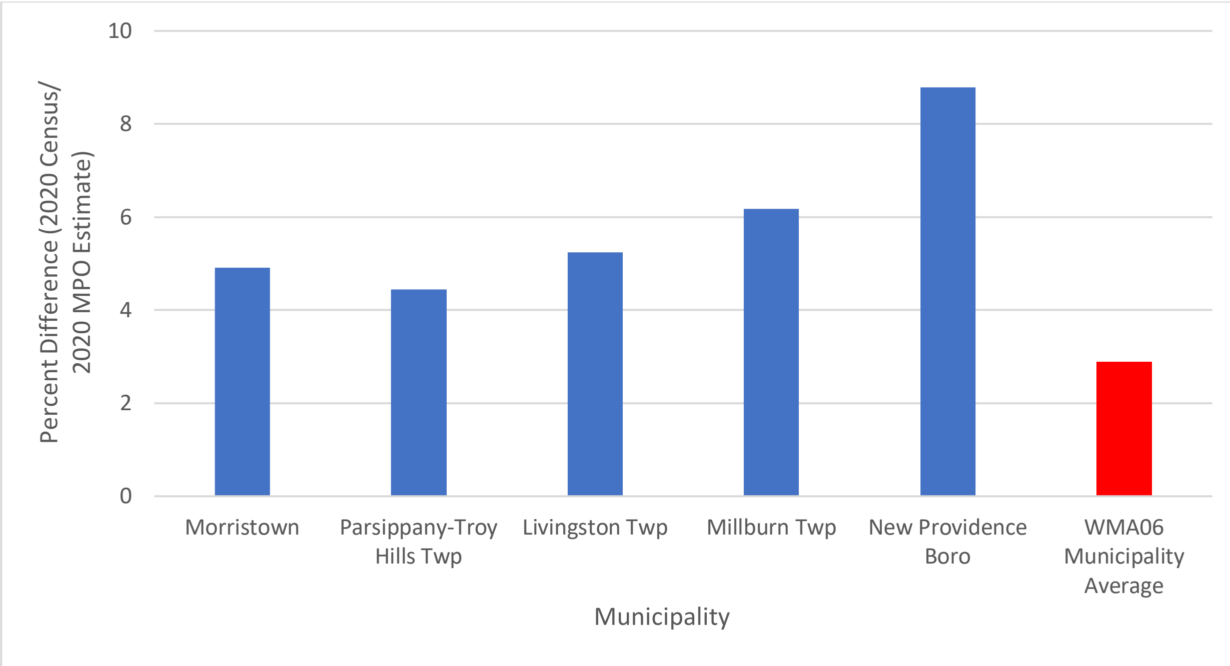


Figure H3a. Percent Difference among WMA06 Focus Municipalities (2020 Census Population/ 2020 MPO Population Projection)

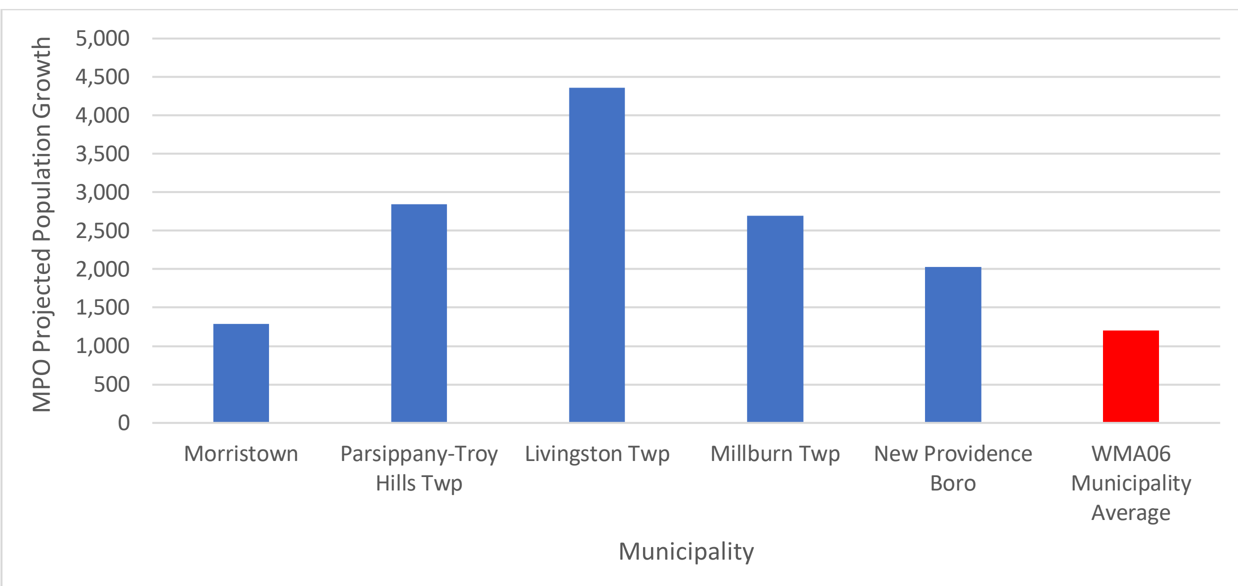


Figure H3b. MPO Projected Population Growth among WMA06 Focus Municipalities (2020-2050)

5. SOCIAL VULNERABILITY

KEY FINDINGS

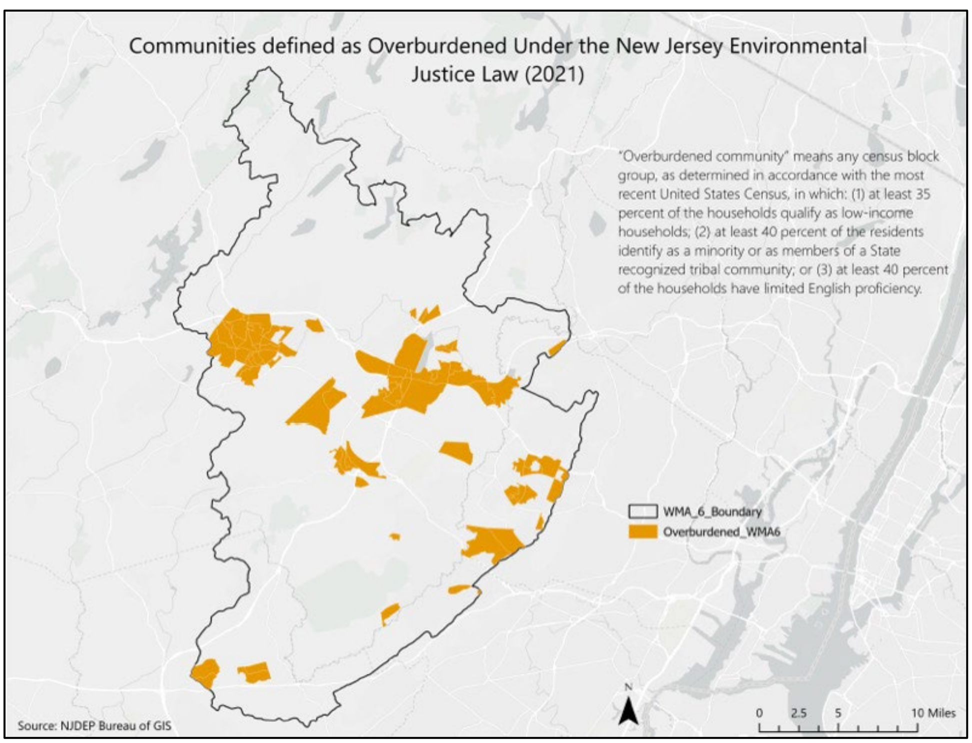
- From examination of NJDEP's Overburdened Communities (as mapped by NJDEP under state law) and the Centers for Disease Control's (CDC's) Social Vulnerability Index (SVI) for the WMA06 region, Essex County was found to have the highest social vulnerability in the region, though this high SVI score may be strongly influenced by municipalities outside of WMA06.
- Although Morris County's SVI score suggests it has low social vulnerability, 17 of its WMA06 municipalities contain Overburdened Communities.
- The WMA06 municipalities with the largest social vulnerability include portions of Morris County's Dover, Victory Gardens Borough, Wharton Borough, and the focus municipalities of Morristown and Parsippany-Troy Hills Township.

5.1 NJDEP OVERBURDENED COMMUNITIES

Two metrics were used to examine social vulnerability in WMA06: the NJDEP Overburdened Communities and CDC's SVI metrics. On NJDEP's website (NJDEP Environmental Justice), Overburdened Communities are defined as:

"…any census block group, as determined in accordance with the most recent United States Census, in which:

1. at least 35 percent of the households qualify as low-income households (at or below twice the poverty threshold as determined by the United States Census Bureau);
2. at least 40 percent of the residents identify as minority or as members of a State recognized tribal community; or
3. at least 40 percent of the households have limited English proficiency (without an adult that speaks English "very well" according to the United States Census Bureau)."



Map H4. Map of WMA06 Census Blocks Identified as Overburdened Communities

County	Number of Municipalities with Overburdened Communities	Municipality Name
Morris	17	Boonton Town, Chatham Township, Dover, Florham Park Borough, Hanover Township, Jefferson Township, Madison Borough, Mine Hill Township, Montville Township, Morris Township, Morristown, Parsippany-Troy Hills Township, Randolph Township, Rockaway Township, Roxbury Township, Victory Gardens Borough, Wharton Borough
Essex	7	Caldwell Borough, Cedar Grove Township, Fairfield Township, Livingston Township, Millburn Township, West Caldwell Township, West Orange Township
Somerset	2	Bernards Township, Bridgewater Township
Sussex	0	
Union	1	Summit City

Table H3. WMA06 Municipalities with Overburdened Communities
Source: NJDEP Office of Environmental Justice, 2022

Map H4 shows the WMA06 census block groups that are designated as Overburdened Communities. As shown in the map and Table H3, the majority of Overburdened Communities in WMA06 are located in Morris County, followed by Essex County. Four out of the five focus municipalities (Morristown, Parsippany-Troy Hills Township, Millburn Township, and Livingston Township) have census blocks containing Overburdened Communities.

Focus Municipality	Number of Census Block Groups Overburdened	Census Block Group Numbers	Overburdened Community Criteria in Census Block Groups
Morristown	8	340270435001, 340270435002, 340270436021, 340270438023, 340270438011, 340270435003, 340270436022, 340270438021	Minority, Low Income and Minority, Low Income, Minority, and Limited English
Parsippany-Troy Hills Township	27	340270416043, 340270417041, 340270418022, 340270418023, 340270418024, 340270418033, 340270417015, 340270416021, 340270416032, 340270416041, 340270417011, 340270416052, 340270416053, 340270416061, 340270416062, 340270417063, 340270417064, 340270417013, 340270417014, 340270417021, 340270417023, 340270417043, 340270417051, 340270417062, 340270418012, 340270418011, 340270418021	Minority, Low Income and Minority, Minority and Limited English

Focus Municipality	Number of Census Block Groups Overburdened	Census Block Group Numbers	Overburdened Community Criteria in Census Block Groups
Livingston Township	10	340130204002, 340130205001, 340130205003, 340130205005, 340130206003, 340130206005, 340130207002, 340130207003, 340130208001, 340130207004	Minority
Millburn Township	9	340130201001, 340130201002, 340130201003, 340130202002, 340130202003, 340130203001, 340130203003, 340130200006, 340130203002	Minority, Low Income and Minority

Table H4. Overburdened Communities in WMA06 Focus Municipalities
Source: NJDEP Office of Environmental Justice, 2022

Table H4 describes the type of vulnerability found in the Overburdened Communities in WMA06's focus municipalities based on NJDEP's definition of Overburdened Community. All of these communities have census block groups with at least 40 percent of the residents identifying as minority. Morristown, Parsippany-Troy Hills Township, and Millburn Township all contain census blocks that have at least 35 percent of the households qualifying as low-income in addition to meeting the definition's minority criteria. Both Morris County focus municipalities, Morristown and Parsippany-Troy Hills, also have census blocks that meet the limited English criteria for NJDEP's Overburdened Community definition.

5.2 SOCIAL VULNERABILITY INDEX (SVI)

The Social Vulnerability Index (SVI) was originally created by the Agency for Toxic Substances and Diseases Registry's (ATSDR's) Geospatial Research, Analysis & Services Program to help public health officials and emergency responders identify communities most likely to require support after hazardous events. In this index, U.S. Census tracts are ranked against each other on 15 social factors (such as disability and unemployment) that are categorized into four themes (Socioeconomic Status, Household Composition and Disability, Minority Status and Language, and Housing Type and Transportation). Each tract receives a rank for each factor, each of the four themes, and overall vulnerability, which can also be aggregated to a county level. SVI percentile rankings are based on a score of 0 to 1, in which census-tracts (or counties) with higher values have greater vulnerability compared to other tracts (or counties). In comparing the two vulnerable community metrics used in this assessment (Overburdened Communities and SVI), the Socioeconomic Status and Minority Status and Language SVI themes most closely align with the Overburdened Community metric. The other two SVI themes (Household Composition and Disability and Housing Type and Transportation) provide additional information about WMA06's socially vulnerable communities (Centers for Disease Control and Prevention Agency for Toxic Substances and Diseases Registry, 2022).

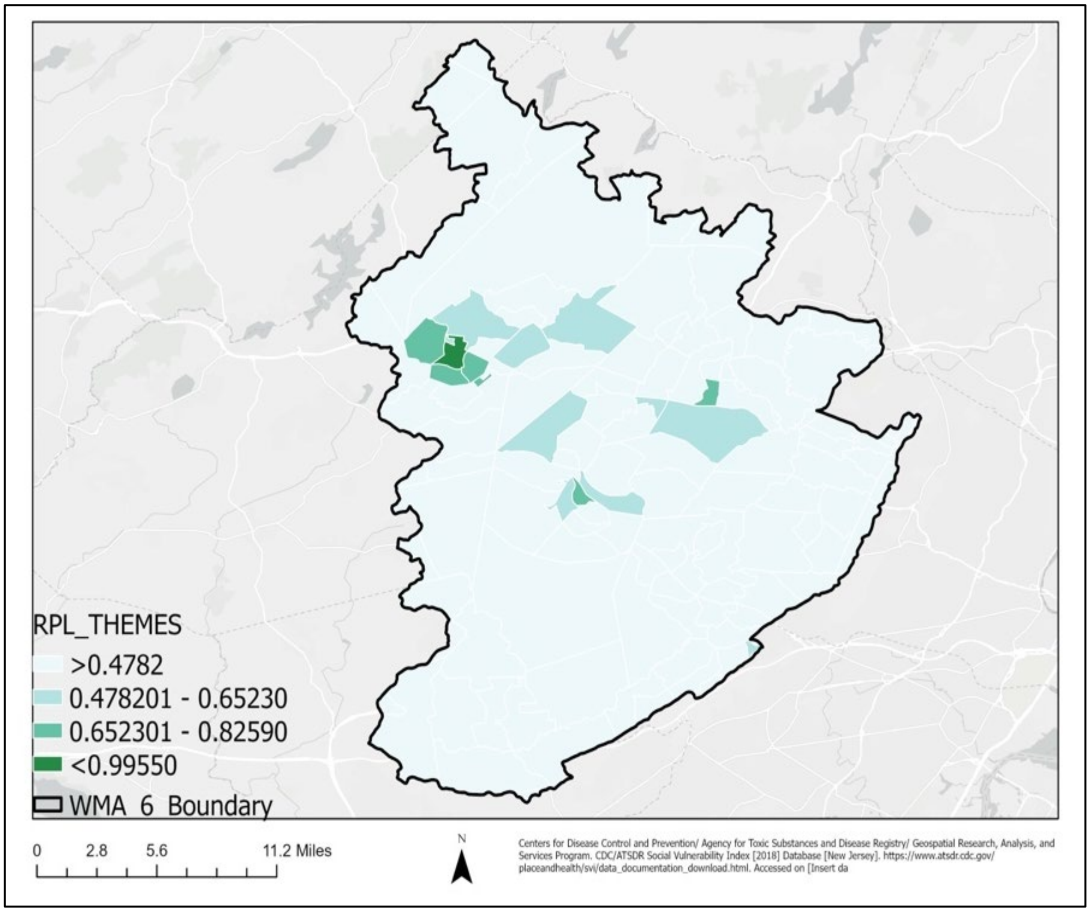
Table H5 provides the percentile ranking values for each of the major SVI categories and the total SVI percentile rankings for each WMA06 county (Also see Map H5). Ranking values are based on a comparison of all New Jersey counties between 0 (lowest vulnerability in the State) and 1 (highest vulnerability in the State). WMA06 has a wide range of SVI scores, with Sussex, Somerset, and Morris counties having relatively low SVI scores, ranking second, third, and fourth lowest in total SVI scores in the state respectively. In addition, these counties also have very low Socioeconomic Status, Household

Composition and Disability, and Housing Type and Transportation percentile rankings. The Household Composition and Disability percentile ranking considers single-parent households and the number of citizens aged 65 or older, aged 17 or younger, or with a disability. The Socioeconomic Status category considers citizen income, the number of citizens who are living below poverty level, are unemployed, and/or have no high school diploma. The Housing Type and Transportation percentile ranking considers factors such as the number of citizens living in mobile homes, group quarters, and multi-unit structures, experiencing crowding, and/or have no vehicle. The overall scores for Sussex, Somerset, and Morris counties suggest that these counties are the least vulnerable out of the WMA06 counties.

County	Socioeconomic Status Percentile Ranking	Household Composition and Disability Percentile Ranking	Minority Status and Language Percentile Ranking	Housing Type and Transportation Percentile Ranking	Total Social Vulnerability Index Percentile Ranking
Essex	0.90	0.75	0.85	0.85	0.90
Morris	0.05	0.05	0.45	0.15	0.15
Somerset	0.05	0.10	0.50	0.00	0.10
Sussex	0.15	0.10	0.00	0.00	0.05
Union	0.55	0.45	0.85	0.55	0.60

Table H5. Social Vulnerability Index Percentile Values for WMA06 Counties (2018)
Data courtesy of CDC ATSDR Geospatial Research, Analysis, and Services Program, 2020

As shown in Table H5, four out of the five WMA06 counties have relatively high rankings in Minority Status and Language, even among Morris and Somerset counties. This reflects the high resident diversity of the region. While Union County has relatively average SVI scores compared to the rest of the state, Essex County has significantly high SVI scores in all considered categories. Essex County's scores are significantly higher than the other WMA06 counties, which suggests it is the most vulnerable county in the WMA06 region. However, this is a bit of a misrepresentation of WMA06's Essex municipalities, which are less vulnerable compared to areas in the eastern side of the county. Among WMA06 municipalities, the highest SVI scores are located in areas of Dover, Victory Gardens Borough, and Wharton Borough, along with portions of Morristown and Parsippany-Troy Hills Township.



Map H5. WMA06 Social Vulnerability Index (2018): Overall Municipality Score

5.3 COMPARISON OF OVERBURDENED COMMUNITIES AND SVI FINDINGS

Overall, the SVI and Overburdened Communities results for WMA06 are consistent in identifying the WMA06 locations that are most socially vulnerable. Communities identified as having the highest SVI scores in WMA06 (Dover, Victory Gardens Borough, Wharton Borough, and portions of Morristown and Parsippany-Troy Hills Township) were all found to contain census block groups designated as Overburdened Communities. Also consistent from the comparison of SVI and Overburdened Communities findings was identifying Essex County as the most socially vulnerable WMA06 county. Seven of Essex County's eleven WMA06 municipalities contain Overburdened Communities. As a percent of its total WMA06 municipalities, Essex County has the highest percentage of municipalities containing Overburdened Communities (64%), followed by Morris County (55%).

The finding that 17 of Morris County's WMA06 municipalities contain Overburdened Communities may appear contradictory compared to its SVI findings, which suggested low vulnerability. Because the SVI scores are based on a ranking process, findings for Morris County are interpreted as Morris County has low vulnerability compared to other New Jersey counties (third lowest vulnerability among WMA06 counties and fourth lowest vulnerability among New Jersey counties). However, the Overburdened Communities analysis reveals that Morris County contains vulnerable communities regardless of how they compare to communities in other locations. Therefore, the use of the Overburdened Community

designation along with the SVI analysis helped to provide a more comprehensive picture of social vulnerability in WMA06.

6. CURRENT LAND USE

KEY FINDINGS

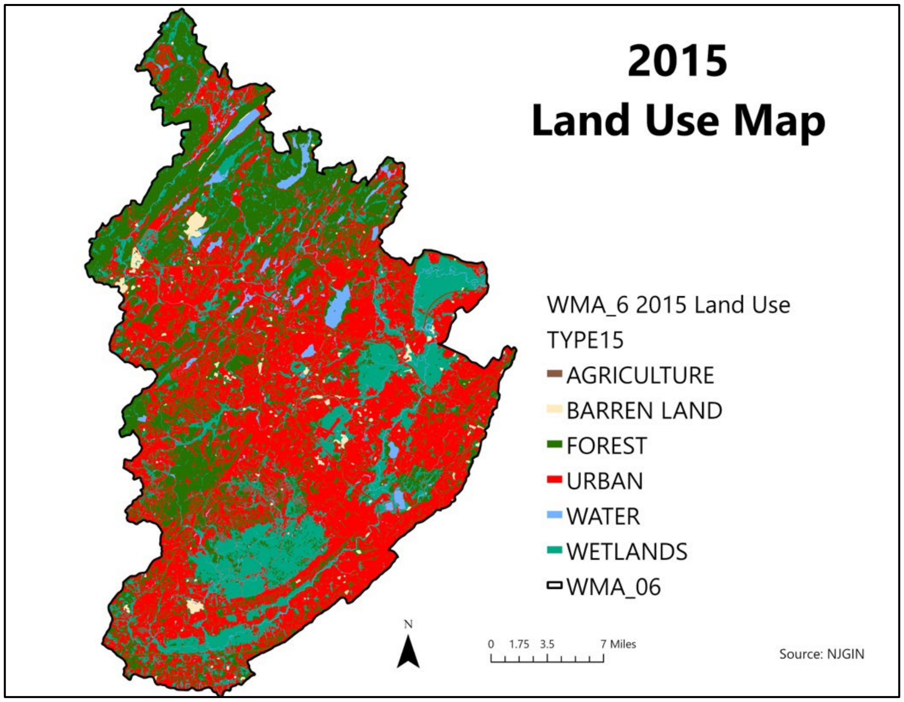
- WMA06 is dominated by urban (32%) and forest (32%) land use/land cover, and is considered heavily developed. Facing regional development limitations from Highlands regulations, development strategies in Morris, Essex, and Somerset counties have focused on urban redevelopment and infill projects.
- A small agricultural presence exists in several WMA06 counties (Morris, Sussex, and Somerset), and WMA06 efforts to preserve open space focus on areas that provide flood protection and aquifer recharge.

	Urban	Agriculture	Forest	Barren Land	Wetlands	Water
WMA06 Region	32%	1%	32%	1%	17%	3%
Focus Municipalities						
Livingston Township	64%	0%	19%	0%	14%	3%
Millburn Township	64%	0%	22%	0%	7%	6%
Morristown	82%	0%	12%	0%	1%	3%
Parsippany-Troy Hills Township	57%	0%	20%	1%	16%	7%
New Providence Borough	83%	0%	10%	1%	5%	1%

Table H6. Land Use in WMA06 and Focus Municipalities (2015)
Data provided by NJDEP Bureau of GIS, 2019

Table H6 provides the 2015 land use data for the WMA06 region and its focus municipalities (also see Map H6). As shown in the table, WMA06 has significant land use/land cover in natural areas, with 2015 reports of 32% forest, 3% water, and 17% wetlands, a significant portion of which is preserved open space. However, these areas are smaller in the focus municipalities. WMA06's highly developed land use is reflected in its reported 2015 regional urban land use percentage, which is 32%. Several significant wetlands areas are located in WMA06 including Passaic-Great Piece, Troy Meadows, Hatfield Swamp, and the Great Swamp. These wetland areas provide stormwater and flood storage and other environmental benefits to the region (Highlands Council, 2008a; Burgis Associates, Inc., 2011; Rutgers Cooperative Extension, 2007).

Despite facing development limits from both Highlands regulations (within the Highlands Preservation Area and conforming municipalities within the Planning Area) and lack of available vacant land, many WMA06 counties have developed strategies to promote development. For example, both Morris and Essex counties' development strategies have focused on redevelopment and infill projects in urban locations (Morris County Department of Public Works & Morris County Planning Board, 2018; Tetra Tech, 2020b). Facing similar issues with little remaining vacant developable land in sewer service areas, Somerset County planners also anticipate that any higher-intensity growth would also be in the form of infill and redevelopment projects (Somerset County Mitigation Planning Committee, 2019); little of the county's WMA06 area is within sewer service areas. Sussex County has focused on preventing suburban sprawl, and is interested in promoting a centers-based land use structure that has higher-density land use near development centers (Morris Land Conservancy & Sussex County Agriculture Development Board, 2008).



Map H6. WMA06 2015 Land Use Map

6.1 FARMLAND PRESERVATION AND OPEN SPACE

Despite being heavily developed, a small agricultural presence exists in several WMA06 counties. Morris County agriculture is concentrated in the southwest and northern areas of the county (Morris County Planning Board, 2013); the farmland within Washington Township to the southwest is mostly within the Raritan River Basin (WMA08). With estimates Morris County has over 60,000 acres of prime farmland and over 31,000 acres of statewide importance, Morris County's Farmland Preservation Program has preserved over 8,000 acres of farmland as of 2021 (Heyer Gruel & Associates & Morris County Office of Planning & Preservation, 2022). The 2017 Census of Agriculture reported Morris County to have a total of 418 farms and 14,514 acres of agricultural land, far less than the total acreage of prime farmland. The median size of farms was 12 acres, and Morris County's market value of agricultural products sold was $24,824,000 (National Agricultural Statistics Service, 2019a; National Agricultural Statistics Service, 2019b). Known for its production of crops including corn, hay, and livestock, the 2017 Agricultural Census reported Sussex County had 1,008 farms and 59,766 acres of agricultural land; much of this land is outside WMA06. Its median farm size was larger than Morris County's (18 acres), but its market value of agricultural products sold was smaller ($18,226,000) (Morris Land Conservancy & Sussex County Agriculture Development Board, 2008; National Agricultural Statistics Service, 2019a; National Agricultural Statistics Service, 2019b). Somerset County's agricultural industry is considered small, but has strong public support (Somerset County Board of Chosen Freeholders et al., 2013), with approximately 8,300 acres of permanently preserved farmland, part of which is outside of WMA06. All of the WMA06 Somerset municipalities contain small areas of agricultural land use, with a 2019 estimate of 4,168 acres of agricultural land in these municipalities (Somerset County Planning Board, 2022).

WMA06's counties have also made efforts to preserve their open space, which has included a focus on providing flood protection and aquifer recharge. Highlights of WMA06 county efforts to preserve open space are provided below.

- **Morris County**: is highly active in open space preservation and as of 2020, had the largest New Jersey park system with over 18,900 acres. Its open space areas include Morristown National Historic Park and Great Swamp National Wildlife Refuge, both of which are federal facilities (Morris County Planning Board, 2013; Tetra Tech, 2020a). Areas considered high priority for preservation in the county include areas where wellhead protection areas overlap with aquifer recharge areas (MCMUA, 2021).
- **Essex County**: has an extensive park system that as of 2014, included over 7,000 acres of state, county, and municipal open space. Significant open space areas in the county include South Mountain Reservation (1,838 acres), West Essex Park (1,100 acres located along the Passaic River), and Passaic Meadows Macrosite: a NJDEP designated natural heritage priority site located along the Passaic River in Roseland Borough, West Caldwell Township, and Fairfield Township (Hatch Mott MacDonald, 2014).
- **Somerset County**: has a park system that includes over 27 park areas and approximately 14,700 acres. The county's open space preservation strategy includes assisting its municipalities with buyouts of flood-prone residential properties through its Somerset County Municipal Flood Mitigation Funding Program (Somerset County Board of County Commissioners et al., 2022), mostly in the Raritan River Basin.

6.2 NEW JERSEY HIGHLANDS REGION REGULATIONS AND OVERSIGHT

The New Jersey Highlands Region is part of a larger four-state Highlands geological system that spans across 3.5 million acres in New York, Pennsylvania, Connecticut, and New Jersey. The New Jersey Highlands is a 1,343 square mile area that includes all or parts of 88 municipalities in seven counties in northwestern New Jersey (Hunterdon, Warren, Morris, Passaic, Sussex, Bergen, and Passaic) (Highlands Council, 2008b; Tetra Tech, 2020a; Morris County Planning Board, 2013). Considered a significant potable water source for over half of New Jersey's residents, the Highlands Water Protection and Planning Act of 2004 established extensive land use controls in the Highlands Preservation Area, administered by NJDEP, and mandated that the Highlands Council create a Highlands Regional Master Plan (RMP), which established additional land development standards within the region (Highlands Council, 2008b; Tetra Tech, 2020a; Tetra Tech, Inc., 2021; Morris County Planning Board, 2013).

Within the RMP, areas in the New Jersey Highlands region are designated as either Planning Area or Preservation Area. County and municipal conformance to the RMP is mandatory in the Preservation Area and is designed to include lands with the highest ecological value. County and municipal conformance to the RMP is voluntary in the Planning Area. Land is further categorized into three major land use zones: (a) Protection Zones (which focus on protecting the highest quality resources); (b) Conservation Zones (which include significant agricultural lands and associated natural resource lands); and (c) Existing Community Zones (which have fewer natural resource constraints than the first two categories, are more easily served with public infrastructure, and are considered opportune areas for future growth). Restrictions in the Highlands include water withdrawal limits, limits on roadway expansion, restrictions on public water and sewer service extensions, and new environmental standards (Highlands Council, 2008b; Morris County Department of Public Works & Morris County Planning Board, 2018).

Two focus municipalities (Parsippany-Troy Hills Township and Morristown) are located within the Highlands Planning Area. According to the New Jersey Highlands Council website (New Jersey Highlands

Council RMP Conformance Status), Parsippany-Troy Hills received approval for its petition to the Highlands Council for conformance in 2020. Morristown has not petitioned the Highlands Council for conformance (Highlands Council, 2023).

7. WATER AVAILABILITY AND DEMAND ANALYSIS

KEY FINDINGS

- Overall WMA06 withdrawals have declined since the 1990s, and have been a roughly even split between water withdrawals from surface water and unconfined groundwater sources throughout the considered time period (1990-2020). During this time period, almost all water withdrawals were for potable supply purposes.
- WMA06 HUC11s with the largest average withdrawals between 2016-2020 were 02030103030 (Rockaway River) and 02030103010 (Passaic River Upr (above Pine Bk br). A significant portion of WMA06 water withdrawals from 02030103030 are exported out of WMA06 for potable supply use in Jersey City and municipalities that receive water from the city.
- The largest consumptive/depletive water use in WMA06 between 1990-2020 was for potable supply purposes.
- NJDEP's Low Flow Margin analysis reveals two of four WMA06 HUC11s are unstressed, and the HUC11s with the largest deficits are 02030103020 (Whippany River) followed by 02030103010 (Passaic River Upr (above Pine Bk br)).
- The Upper Passaic, Rockaway, and Whippany rivers have all been found to suffer some water quality impairment, with elevated levels of nutrients including Phosphorus, Sodium, and Lead.

Figure H4a and b show WMA06 water withdrawals from 1990-2020 based on water withdrawal source and water use categories. Water withdrawals were roughly split between surface water sources and unconfined groundwater sources throughout the considered time period (1990-2020). However, overall water withdrawal in the region has declined in recent years, with WMA06 water withdrawals averaging a little over 36,700 million gallons a year (36.7 billion gallons a year) between 2010-2020 (compared to a little over 42,000 million gallons a year between 2000-2009) (NJDEP Division of Water Supply and Geoscience, 2021).

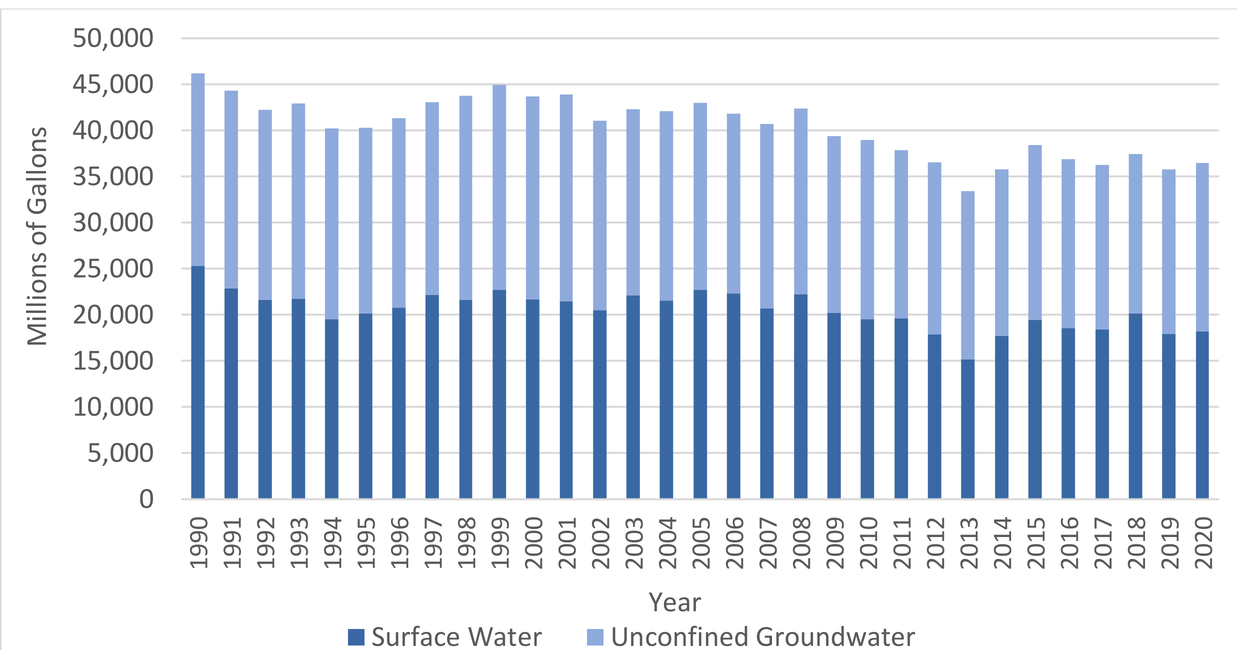


Figure H4a. WMA06 Water Withdrawals by Source (1990-2020)

Water withdrawal by water use category reveals that WMA06 water withdrawals were almost entirely (approximately 97%) for potable supply use throughout the considered time period, with potable supply

withdrawals averaging approximately 39,309 million gallons a year. A small amount of water withdrawals was used for agriculture and irrigation and commercial, industrial, and mining purposes in WMA06 (NJDEP Division of Water Supply and Geoscience, 2021).

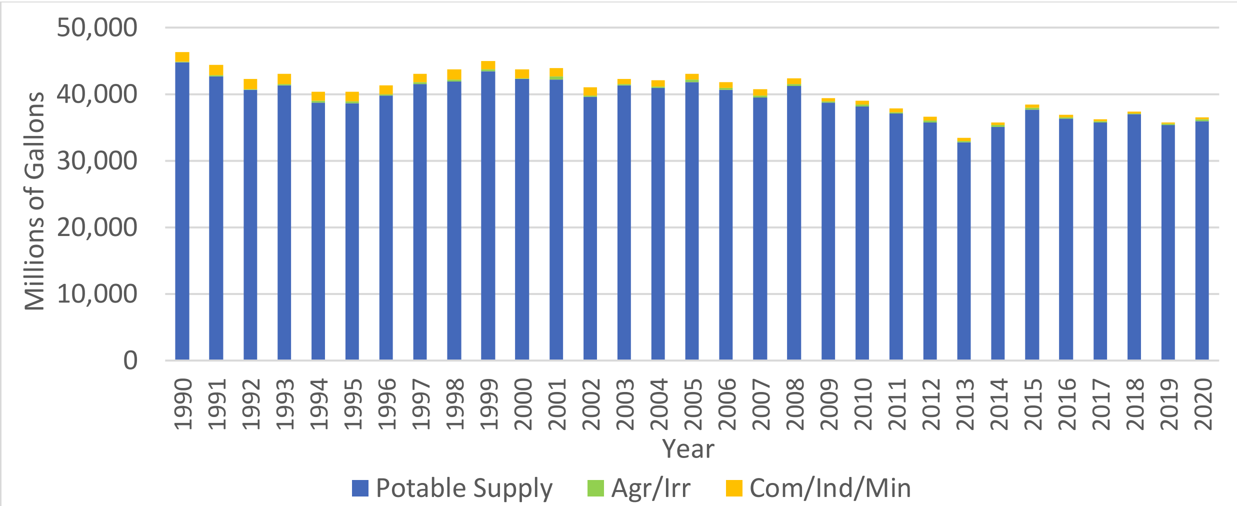


Figure H4b. WMA06 Water Withdrawals by Water Use Category (1990-2020)

Figure H5 shows WMA06 sanitary sewer discharges (returns) to groundwater and surface water resources from 1990-2020. As shown in the figure, WMA06 returns averaged a little over 16,500 million gallons a year between 1990-2020. The average WMA06 water returns between 2010-2020 was approximately 15,864 million gallons a year, which is smaller than the average returns experienced between 2000-2009 (approximately 17,742 million gallons a year). WMA06 returns were almost entirely to surface fresh water sources (average of 99% of total returns between 1990-2020). The largest sources of discharge to surface fresh water sources include Parsippany-Troy Hills STP and Rockaway Valley Regional SA, which were an average of 25.6% and 19.5% of total WMA06 annual discharges from 1990-2020, respectively (NJDEP Division of Water Supply and Geoscience, 2021). Multiple smaller but significant discharges exist in the Whippany River and Upper Passaic River watersheds.

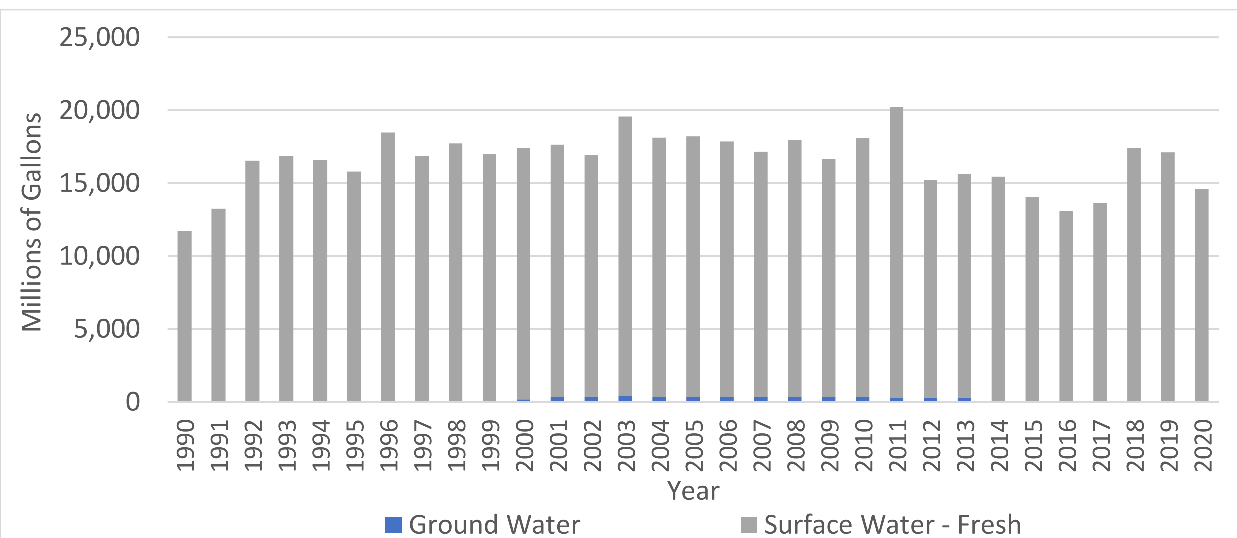


Figure H5. WMA06 Sanitary Sewer Returns by Source (1990-2020)

7.1 WATER QUANTITY

Figure H6 shows the average water withdrawals for each HUC11 in WMA06 based on water use category between 2016-2020. HUC11 02030103030 (Rockaway River) had the largest average water withdrawal between 2016-2020, which was approximately 19,700 million gallons a year. This water withdrawal, like the water withdrawal for the other WMA06 HUC11s, was almost entirely for potable supply purposes. The HUC11s with the next largest withdrawals were 02030103010 (Passaic River Upr (above Pine Bk br)) and 02030103020 (Whippany River). Both of these HUC11s had average withdrawals of approximately 10,418 and 6,410 million gallons a year for the five-year period, respectively (NJDEP Division of Water Supply and Geoscience, 2021).

Most withdrawals from HUC11 02030103030 (Rockaway River) are from the Boonton (Jersey City) Reservoir and are exported from WMA06 for use by the City of Jersey City and its customers. Between 2016-2020, withdrawals by the City of Jersey City were approximately 78% of all withdrawals in this HUC11. This water withdrawal is also a significant portion of both surface water and total water withdrawals in WMA06. Between 2016-2020, water withdrawals by Jersey City were approximately 82% of WMA06's total surface water withdrawals and 42% of WMA06's total withdrawals (NJDEP Division of Water Supply and Geoscience, 2021). These withdrawals are from reservoir storage, as supported by flows of the Rockaway River including both base flows and runoff. The reservoir is subject to mandatory flow contributions to the lower Rockaway River.

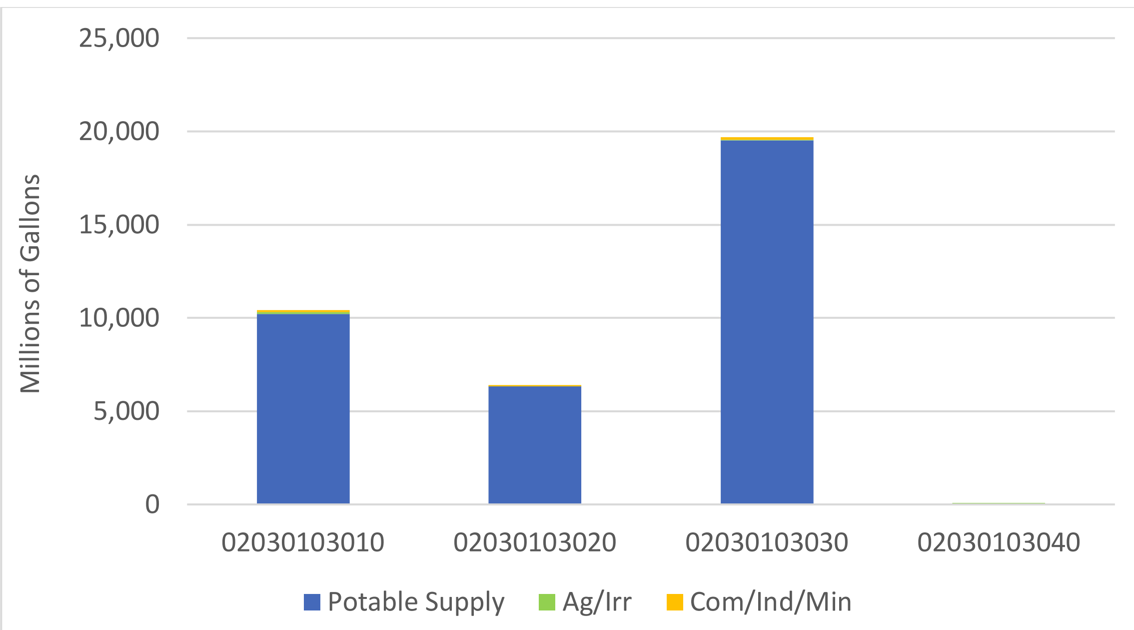


Figure H6. WMA06 HUC11 Five-Year Average Water Withdrawals by Water Use Category (2016-2020)

Figure H7 provides the annual consumptive water use in WMA06 by water use category between 1990-2020. Consumptive water use is considered water that is removed from a water source, used, and ultimately lost (often through evapotranspiration processes), which can vary by water use category (since a different percentage of water evaporates for different water uses) and in different seasons. Therefore, Figure H7 reflects the total annual amount of consumptive water use for each water use category in WMA06 between 1990-2020 (NJDEP Division of Water Supply and Geoscience, 2021).

As shown in Figure H7, potable supply had the largest consumptive water use among WMA06's water use categories throughout the considered time period. Total consumptive water use fluctuated between 1990-2020, with an average total consumptive use of approximately 2,898, 3,228, and 2,905 million gallons a year in the 1990s, 2000s, and 2010s respectively. This indicated a rise in consumptive water use between 2000-2009, and a decline in consumptive use after 2010 that reflected similar numbers to those experienced in the 1990s. Potable supply has slightly increased as a percentage of WMA06's total consumptive water use throughout the considered time period. Potable supply was approximately 89%, 90%, and 92% percent of WMA06's total consumptive water use in the 1990s, 2000s, and 2010s, respectively (NJDEP Division of Water Supply and Geoscience, 2021).

Depletive water uses exist where water is removed from its source area and discharged in another HUC11 or tidal waters. The Jersey City withdrawals are 100% depletive, while other withdrawals will have a consumptive water use component with the rest discharged back to the HUC11 as treated wastewater. Depletive water uses are tracked separately.

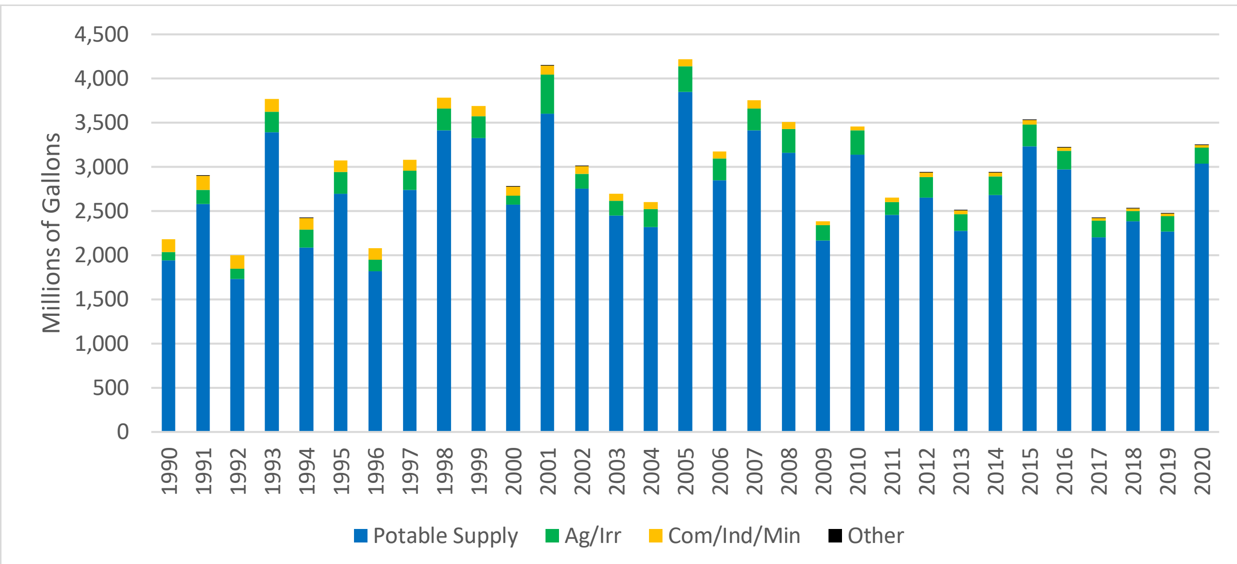


Figure H7. WMA06 Consumptive Water Use by Water Use Category (1990-2020)

Figure H8 provides WMA06 monthly consumptive water use data by water use category between 2005-2020. Potable supply had the largest consumptive water use among the water use categories, but potable supply consumptive water use in WMA06 has declined since 2015. Average consumptive water use for potable supply was approximately 2,898 million gallons a year between 2005-2015, which declined to approximately 2,574 million gallons a year between 2016-2020. The large peaks for potable supply show the seasonality of consumptive water use for this water use category in which the largest consumptive water use is experienced in the summer months (May-September). Consumptive water use for agriculture/irrigation purposes was also found to have a seasonal effect in which consumptive water use was larger in the summer months. However, this effect was on a much smaller scale (primarily due to the limited agricultural presence in WMA06) (NJDEP Division of Water Supply and Geoscience, 2021).

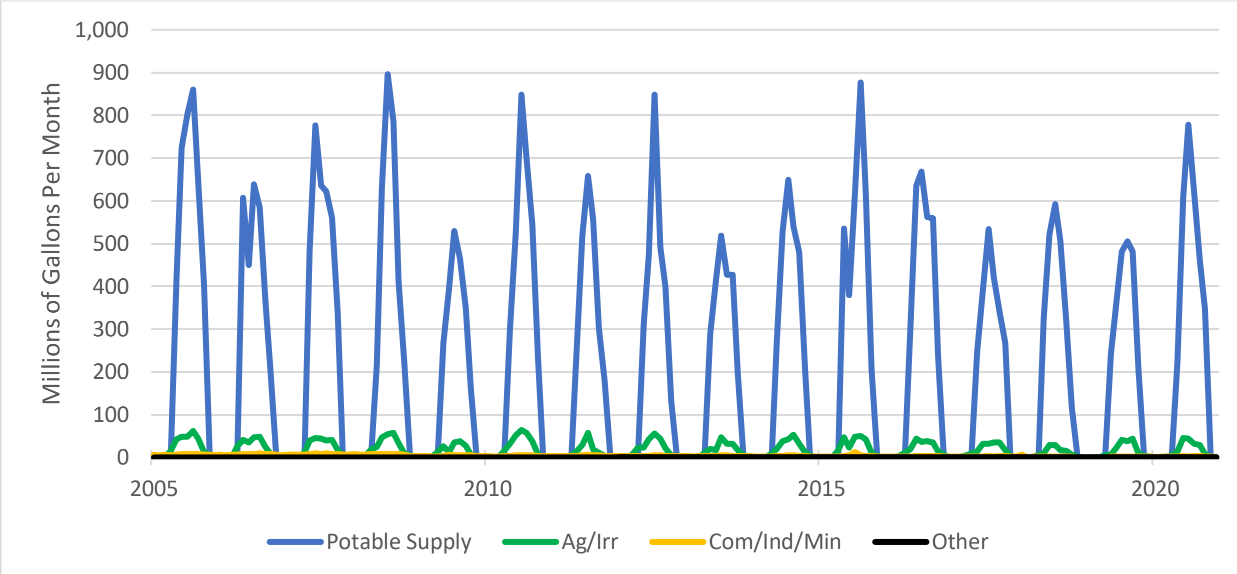


Figure H8. WMA06 Monthly Consumptive Water Use by Water Use Sector (2005-2020)

LOW FLOW MARGIN METHOD

NJDEP uses the streamflow Low Flow Margin (LFM) method to consider what HUC11s may be stressed based on their largest three-year running average (peaks) in consumptive/depletive water loss, regarding use of the unconfined (surficial) aquifer and non-reservoir surface waters (reservoir-based systems and confined aquifers are addressed separately). Figure H9a and b show the amount of available water used in each HUC11 during their three-year average peaks in consumptive/depletive loss between 2011-2020. The only HUC11 with net gain in WMA06 (02030103030 – Rockaway River), is indicated in green in both figures. This net gain is primarily due to the Parsippany-Troy Hills STP discharge at the base of the HUC11, representing wastewater not only from the lower Rockaway River watershed but also from the Whippany River and Upper Passaic watershed (including East Hanover). In both figures, any HUC11 with depletive/consumptive loss greater than 100% water available for the watershed is indicated in red and is considered vulnerable or stressed.

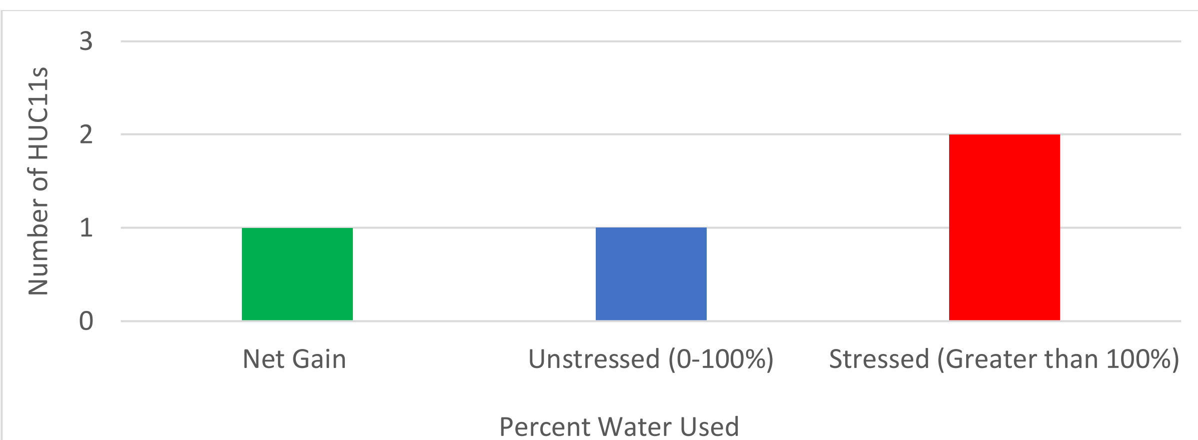


Figure H9a. WMA06 HUC11 Count by Percentage of Total Available Water Used (Three-Year Rolling Average Peak in Depletive/Consumptive Loss between 2011-2020)

As shown in Figure H9b, two out of four WMA06 watersheds are considered unstressed during their respective three-year average peaks in consumptive/depletive loss. The HUC11 considered most

stressed in WMA06 is 02030103020 (Whippany River). Of the four HUC11s, potable supply is identified as the largest source of consumptive/depletive loss for three of four HUC11s, including both stressed HUC11s (02030103010 - Passaic River Upr (above Pine Bk br) and 02030103020 - Whippany River) in WMA06. The largest source of consumptive/depletive loss in 02030103030 (Rockaway River) is non-agricultural irrigation (NJDEP Division of Water Supply and Geoscience, [forthcoming]).

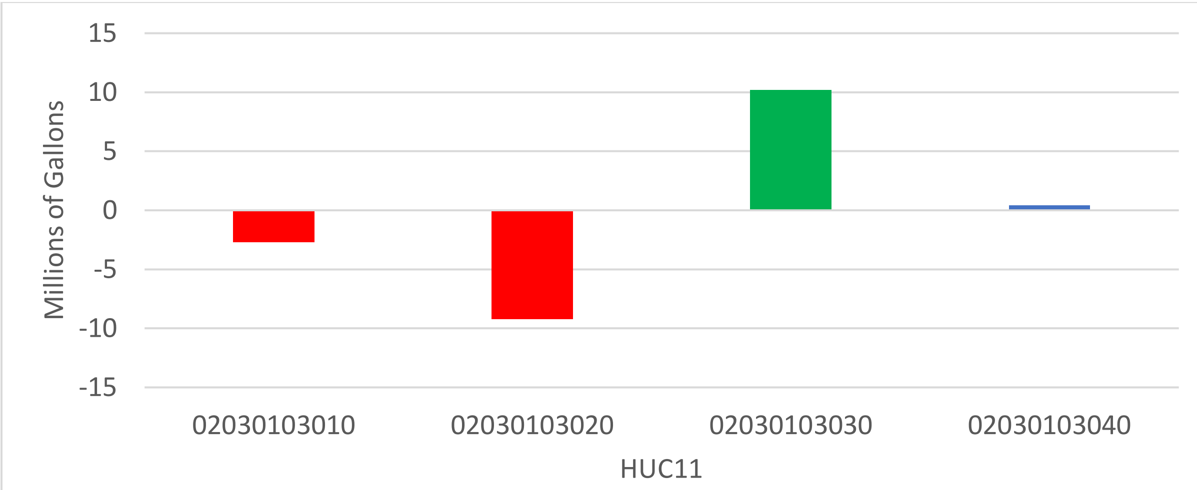


Figure H9b. WMA06 HUC11 Remaining Available Water for Three-Year Rolling Average Peaks in Consumptive/Depletive Loss (2011-2020)

7.2 WATER QUALITY

Extensive development of WMA06 has contributed to water quality impairment of the Upper Passaic, Rockaway, and Whippany rivers. Highlights of the water quality conditions of WMA06's three major rivers are provided below.

- **The Upper Passaic River**: traditionally has better water quality than the highly developed and industrialized locations downstream. However, the Upper Passaic River watershed does have water quality concerns. According to NJDEP's 2018/2020 New Jersey Integrated Water Quality Assessment Report, portions of the Upper Passaic River are failing to meet water quality standards in Dissolved Oxygen, Total Suspended Solids, and Total Dissolved Solids. Non-attainment for Total Phosphorus, *E. coli*, and Arsenic (human health) were detected in multiple locations within the Upper Passaic River watershed. These areas included Slough Brook, Canoe Brook, and several areas of the main Upper Passaic River (such as Snyder to Plainfield Road, Rockaway to Hanover Railroad, and Pine Brook to Rockaway) (NJDEP Division of Water Monitoring and Standards, 2021a; NJDEP Division of Water Monitoring and Standards, 2021b). This region faces challenges from suspected non-point sources including leaking septic systems, urban surface runoff, and lawn and garden chemicals (Morris County Planning Board, 2000).
- **The Rockaway River**: historically has had good water quality in the Upper Rockaway watershed compared to below the reservoir in Pine Brook (Montville Township). Previous activities on Superfund and other contaminated sites, such as L.E. Carpenter (Wharton Borough) and Sharkey's Landfill (Parsippany Troy-Hills Township), have been suspected of potentially adding industrial contaminants to the Rockaway River (Morris County Planning Board, 2000). More recently, NJDEP's 2018/2020 New Jersey Integrated Water Quality Assessment Report has found that portions of the Rockaway River have excessive *E.coli*, Arsenic (human health), and Mercury (fish consumption) concentrations (NJDEP Division of Water Monitoring and Standards, 2021a; NJDEP Division of Water Monitoring and Standards, 2021b).

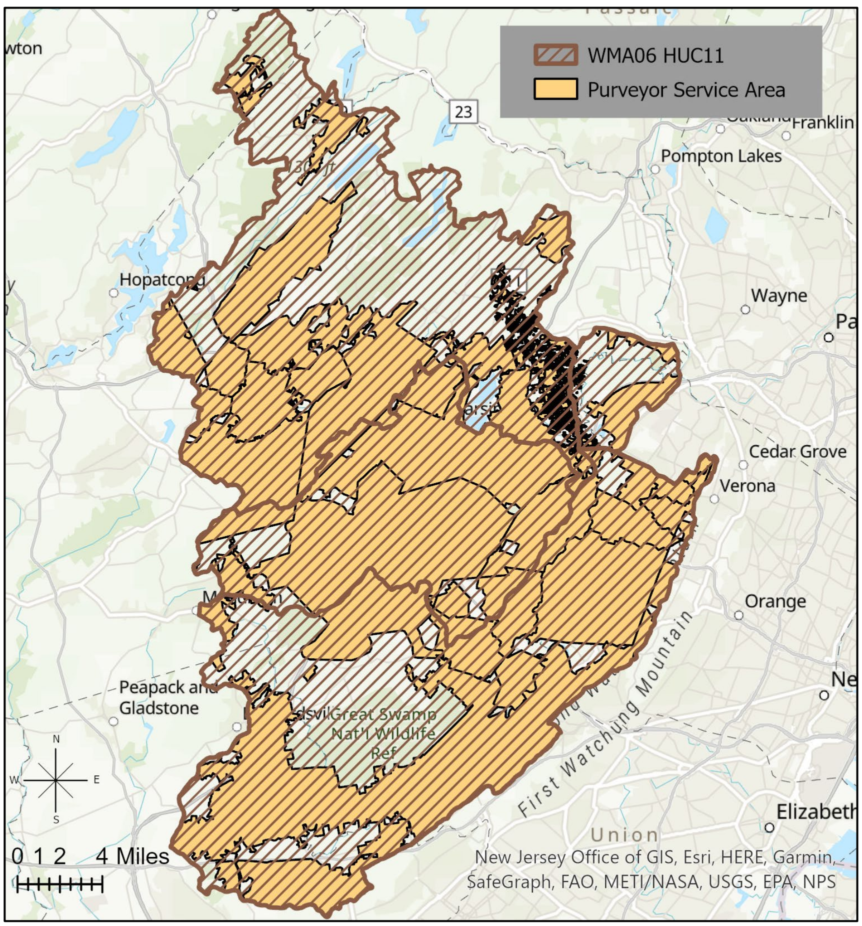
- **The Whippany River**: also faces pollution from nonpoint sources such as surface runoff, groundwater discharges, and fertilizers, and has been historically found to suffer from contamination from fecal coliform, Phosphorus, inorganic Nitrogen, and Sodium (Tetra Tech, 2020b; Colliers Engineering & Design & Hipolit, 2021; Morris County Planning Board, 2000). Water quality testing of the Whippany River for the NJDEP's 2018/2020 New Jersey Integrated Water Quality Assessment Report shows that portions of the Whippany River suffer from elevated concentrations of Total Phosphorus, *E. coli*, Arsenic (human health), and Lead (human health) (NJDEP Division of Water Monitoring and Standards, 2021a; NJDEP Division of Water Monitoring and Standards, 2021b). Examination of local waterbodies that enter the Whippany River, such as Lake Parsippany, have been found to have contamination in lake sediments. In response, basins have been created to prevent contaminated sediments from entering the river (Rutgers Cooperative Extension, 2007).

The Central Passaic Buried Valley Aquifer System and Upper Rockaway River Basin Area Aquifer System are vulnerable to contamination through their recharge zones from sources including septic systems and contaminants in streamflow (Amy S, Greene Environmental Consultants, Inc., 2010). Since the unconfined units are often shallow, they may be vulnerable to pollutants such as gasoline, deicing salts, and industrial chemicals (Highlands Council, 2008b). These aquifer systems are also particularly vulnerable to contamination during drought periods and in locations with heavy pumping, as the aquifer will draw water from surface water sources through lake and river sediments (Highlands Council, 2008c). Other sources that pose a risk to contaminate the recharge zones include leaking pipes, accidental spills, pesticides, and vehicle emissions (Amy S, Greene Environmental Consultants, Inc., 2010). There are several Superfund sites upstream, in areas including Denville Township, Dover, Rockaway Borough and Rockaway Township, mostly involving discharges from industrial facilities and gasoline storage tanks.

8. WATER UTILITIES AND WATER INFRASTRUCTURE

KEY FINDINGS

- PCWSs in WMA06 are highly interconnected due to factors including population density and historical development, which allows for the transfer of water between PCWSs.
- Although roughly half of WMA06's PCWSs reported a decline in potable water demand between 2011-2020, the largest increases in potable supply demand were reported for Jefferson Township Water Utility- Lake Hopatcong, Mount Arlington Borough DWP Main, and Denville Township WD.
- WMA06 PCWS 2050 demands projections indicate that the majority of WMA06 PCWSs will experience less demand compared to current demand numbers, with localized differences between PCWSs in different counties and future water use behavior. However, there is some uncertainty with these numbers due to the uncertainty of the population projections for Morris and Essex counties (discussed in Section 4).
- WMA06 PCWS 2050 demands projections also indicate that many PCWSs serving WMA06's focus municipalities will experience demand decline by 2050, suggesting that they will be able to meet future water demands.



Map H7. Public Community Water System (PCWS) Purveyor Service Areas in WMA06's HUC11s
Source: NJDEP Bureau of GIS

Table H7 shows the public community water systems (PCWSs) that serve over 1,000 people and service the HUC11s in WMA06 (See Map H7 for all PCWS purveyor service areas in WMA06's HUC11s)[1]. Due to factors including high population density and historical development, there are many large PCWSs in WMA06, and they are highly interconnected. In addition to significant WMA06 water withdrawals being exported for use by the City of Jersey City and its customer municipalities, NJDEP reports that many PCWSs within the region also transfer water between each other in bulk transfer agreements, such as from Passaic Valley Water Commission to New Jersey American Water and Southeast Morris County MUA, and from Jersey City to Parsippany-Troy Hills. Regional capability for transferring water between PCWSs in WMA06 has been found to be an effective strategy in regional response to droughts and other water emergencies (NJDEP, Gannett Fleming, & Black & Veatch, 2007).

The largest PCWSs that serve Morris County are Southeast Morris County MUA, Dover WD, and Parsippany-Troy Hills WD. Many of the purveyors in the western part of the county (e.g., Randolph Township) receive water from the Morris County Municipal Utilities Authority (primarily from groundwater in the Raritan River Basin, WMA08), which is responsible for both developing and distributing water supply for county residents (Heyer Gruel & Associates & Morris County Office of Planning & Preservation, 2022). Essex County's largest PCWS is New Jersey American Water. Somerset County has several water service providers including New Jersey American Water – Raritan and New Jersey American Water – Passaic. While roughly half of the listed PCWSs reported a decline in potable water demand, Jefferson Township Water Utility- Lake Hopatcong, Mount Arlington Borough DWP Main, and Denville Township WD reported the largest increase in potable supply demand in WMA06 between 2011 and 2020 (NJDEP Division of Water Supply and Geoscience, 2022a; NJGWS, 2022).

Almost 20% of all major WMA06 PCWSs reported firm capacity deficits. Firm capacity represents the ability of a utility to provide water with its largest unit out of production (e.g., the largest well in a wellfield). East Hanover Township WD (approximately -0.2 mgd), Sisters of Charity of South Elizabeth (approximately -0.1 mgd), Caldwell WD (approximately -1 mgd), and Roseland WD (approximately -2 mgd) all reported firm capacity deficits. Firm capacity deficits were also reported by Rockaway Borough WD (approximately -0.2 mgd) and North Caldwell WD (approximately -0.3 mgd).

Several major WMA06 PCWSs had either monthly or yearly water allocation permit deficits. Mount Arlington Borough DPW Main reported a deficit for both its monthly (approximately -1 mgm) and yearly (approximately -11 mgy) water allocation permits, while Rockaway Township WD reported a deficit in its yearly water allocation permit (approximately -44 mgy). Rockaway Borough WD reported a monthly water allocation permit deficit (approximately -4 mgm), while North Caldwell WD reported deficits in both its monthly (approximately -11 mgm) and yearly (approximately -205 mgy) water allocation permits (NJDEP Division of Water Supply and Geoscience, 2022b).

[1] Please note that PCWSs with very limited acreage in WMA06 were excluded from the assessment.

Purveyor	Purveyor ID	HUC11s Served	Demand Percent Change (2011-2020)	Average Demand (mgy) (2011-2020)	Max Demand (mgy) (2011-2020)
Caldwell WD	NJ0703001	02030103010	-1%	288	304
Essex Fells WD	NJ0706001	02030103010	-9%	180	277
Fairfield WD	NJ0707001	02030103010, 02030103040	5%	489	549
Livingston Township DW	NJ0710001	02030103010	4%	1,435	1,659
NJ American Water- Passaic	NJ0712001	02030103010, 02030103020	-16%	12,445	13,586
North Caldwell WD	NJ0715001	02030103010	-25%	300	374
Roseland WD	NJ0718001	02030103010	-11%	253	282
West Caldwell WD	NJ0721001	02030103010	36%	457	534
Boonton WD	NJ1401001	02030103020, 02030103030	1%	272	293
Chatham WD	NJ1404001	02030103010	13%	324	359
Denville Township WD	NJ1408001	02030103020, 02030103030	36%	736	874
Dover Water Commission	NJ1409001	02030103030	-5%	995	1,085
East Hanover Township WD	NJ1410001	02030103010, 02030103020, 02030103030	31%	694	818
Florham Park WD	NJ1411001	02030103010, 02030103020	12%	377	508
Jefferson Township W U Milton System	NJ1414003	02030103030	-24%	112	136
Jefferson Township Water Utility - Lake Hopatcong	NJ1414011	02030103030	94%	209	268
Fayson Lakes WC	NJ1415001	02030103030	20%	71	84
Lincoln Park WD	NJ1416001	02030103040	-5%	411	507
Madison WD	NJ1417001	02030103010, 02030103020	9%	669	781
Mine Hill WD	NJ1420001	02030103030	-35%	93	148
Montville Township MUA	NJ1421003	02030103010, 02030103030, 02030103040	22%	802	870
Sisters of Charity of South Elizabeth	NJ1422001	02030103020	-47%	16	19
Southeast Morris County MUA	NJ1424001	02030103010, 02030103020, 02030103030	6%	3,033	3,198
Mountain Lakes WD	NJ1425001	02030103020, 02030103030	-7%	195	218

Purveyor	Purveyor ID	HUC11s Served	Demand Percent Change (2011-2020)	Average Demand (mgy) (2011-2020)	Max Demand (mgy) (2011-2020)
Mount Arlington Borough DWP Main	NJ1426005	02030103030	51%	90	111
Parsippany-Troy Hills WD	NJ1429001	02030103020, 02030103030	-2%	2,245	2,422
Randolph Township Public Works Dept	NJ1432003	02030103020, 02030103030	-10%	576	650
Rockaway Borough WD	NJ1434001	02030103030	-42%	338	431
Rockaway Township WD	NJ1435002	02030103030	12%	546	605
AWO&M - Picatinny Arsenal	NJ1435003	02030103030	-22%	226	311
Roxbury Water Company	NJ1436002	02030103030	-19%	352	452
Roxbury Township WD - Skyview*	NJ1436004	02030103030	-100%	18	28
Wharton WD	NJ1439001	02030103030	6%	520	571
Sparta Township WU - Highlands	NJ1918003	02030103030	13%	51	119
NJ American Water - Raritan	NJ2004002	02030103010	1%	35,274	37,257
*Data only available for 2011-2013, 2019					

Table H7. Public Community Water Systems in WMA06 Serving More Than 1,000 People and the HUC11(s) They Serve
Data provided by NJDEP DWSG (NJDEP Division of Water Supply and Geoscience, 2022a; NJGWS, 2022)

Table H8 provides NJDEP 2050 projected demands for major WMA06 PCWSs based on the demand projections provided in Appendix D. Four non-peak 2050 projected demands scenarios were considered, which include nominal and optimal water loss scenarios under a No Conservation and Conservation scenario. Nominal water loss scenarios assume that 2050 water losses will be the same as current median PCWS water losses for service areas in bedrock geology. Optimal water loss scenarios assume that PCWSs will meet a more aggressive water loss standard (25^{th} percentile for the bedrock geology region). No Conservation scenarios assume that recent per capita demands remain stable through 2050, while Conservation scenarios assume a 10% reduction in per capita demands. Surplus/deficit refers to limitations of an Allocation Permit or Water Use Registration minus the sum of demand recorded based on water use records plus demand projected for approved projects. Often, this data can be expressed as either annual (mgy) or monthly (mgm) data, but is expressed as average daily volumes (mgd) in Table H8. Negative surplus/deficit values indicate a shortage in diversion privileges or available supplies through bulk transfer agreements (NJDEP Division of Water Supply and Geoscience, 2022b).

Overall, WMA06 PCWSs are anticipated to experience less demand in 2050 compared to current demand numbers, with some more localized differences between PCWSs in different counties and future water use scenarios. Many PCWSs, especially in Morris County, are projected to experience demand decline (indicating more firm capacity available), including Lincoln Park WD, Mine Hill WD, Montville Township MUA, Southeast Morris County MUA, and Parsippany-Troy Hills WD. Other WMA06 PCWSs projected to experience demand decline include Essex Fells WD, New Jersey American Water – Passaic, and Caldwell WD. Some PCWSs had split projections in which demand was projected to increase in non-conservation scenarios and decline in the conservation scenarios. These PCWSs included Fairfield Township WD and Livingston Township DW. Several PCWSs, such as Rockaway Township WD and East Hanover Township WD, are projected to switch from supply surplus to deficit in some 2050 scenarios. North Caldwell WD, which is currently in deficit, is projected to remain in deficit. Some potential concern was also identified for several PCWSs that were projected to be in deficit in some of their 2050 peak demands scenarios (not provided in Table H8). These PCWSs included West Caldwell Township WD, Denville Township WD, East Hanover Township WD, and Rockaway Township WD.

Among the PCWSs servicing WMA06 focus municipalities, almost all of them are projected to have demand decline by 2050. These PCWSs include New Jersey American Water – Passaic (services New Providence Borough, Livingston Township, and Millburn Township), Southeast Morris County MUA (services Morristown), Denville Township WD, and Parsippany-Troy Hills WD (both service Parsippany-Troy Hills Township). Mountain Lakes WD (also services a small part of Parsippany-Troy Hills Township) and Livingston Township DW were both projected to have demand decline in their conservation scenarios and demand increase in their non-conservation scenarios. As mentioned in the previous paragraph, Denville Township WD did have some projected deficit in its 2050 peak demands scenarios. However, overall findings suggest that PCWSs servicing the focus municipalities will be able to meet future water demands assuming no changes in water availability.

Purveyor ID	Purveyor	Average Daily Demand (2020) (mgd)	2020 Deficit/ Surplus (mgd)	2050 No Conservation Scenario		2050 Conservation Scenario	
				Nominal Water Loss Scenario (mgd)	Optimal Water Loss Scenario (mgd)	Nominal Water Loss Scenario (mgd)	Optimal Water Loss Scenario (mgd)
NJ0703001	Caldwell WD	0.8	1.1	0.8	0.7	0.7	0.7
NJ0706001	Essex Fells WD	0.4	4.2	0.3	0.3	0.3	0.3
NJ0707001	Fairfield Township WD	1.3	1.6	1.5	1.4	1.3	1.3
NJ0710001	Livingston Township DW	3.9	4.9	4.2	4.0	3.8	3.6
NJ0712001	NJ American Water - Passaic	32.2	62.8	31.4	29.9	28.3	27.0
NJ0715001	**North Caldwell WD**	0.8	0.3	0.8	0.8	0.7	0.7
NJ0718001	Roseland WD	0.7	NA	0.7	0.7	0.6	0.6
NJ0721001	West Caldwell Township WD	1.3	1.5	1.0	1.0	0.9	0.9
NJ1401001	Boonton WD	0.7	1.6	0.8	0.7	0.7	0.7
NJ1404001	Chatham WD	0.9	1.2	0.9	0.9	0.8	0.8
NJ1408001	Denville Township WD	2.2	2.5	2.0	2.0	1.8	1.8
NJ1409001	Dover Water Commission	2.6	3.2	2.2	2.1	2.0	1.9
NJ1410001	**East Hanover Township WD**	1.9	2.2	2.4	2.3	2.1	2.0
NJ1411001	Florham Park WD	1.0	1.4	1.0	0.9	0.9	0.8
NJ1414003	Jefferson Township Water Utility - Milton System	0.3	0.4	0.3	0.3	0.2	0.2
NJ1414011	Jefferson Township Water Utility - Lake Hopatcong	0.6	1.0	0.8	0.7	0.7	0.7
NJ1415001	Fayson Lakes WC	0.2	0.2	0.2	0.2	0.2	0.2
NJ1416001	Lincoln Park WD	1.1	2.0	1.1	1.1	1.0	1.0
NJ1417001	Madison WD	1.9	2.5	2.0	1.9	1.8	1.7
NJ1420001	Mine Hill Township WD	0.2	0.5	0.2	0.2	0.2	0.2
NJ1421003	Montville Township MUA	2.3	2.8	2.1	2.0	1.9	1.8

Purveyor ID	Purveyor	Average Daily Demand (2020) (mgd)	2020 Deficit/ Surplus (mgd)	2050 No Conservation Scenario		2050 Conservation Scenario	
				Nominal Water Loss Scenario (mgd)	Optimal Water Loss Scenario (mgd)	Nominal Water Loss Scenario (mgd)	Optimal Water Loss Scenario (mgd)
NJ1422001	Sisters of Charity of South Elizabeth	0.0	0.1	0.0	0.0	0.0	0.0
NJ1424001	Southeast Morris County MUA	8.4	16.0	7.3	7.0	6.6	6.3
NJ1425001	Mountain Lakes WD	0.5	0.8	0.5	0.5	0.5	0.5
NJ1426005	Mount Arlington Borough DWP Main	0.3	0.3	0.2	0.2	0.2	0.2
NJ1429001	Parsippany-Troy Hills WD	6.1	8.4	5.8	5.5	5.2	5.0
NJ1432003	Randolph Township Water Division	1.6	2.5	1.7	1.6	1.5	1.4
NJ1434001	Rockaway Borough WD	0.8	1.5	0.7	0.7	0.7	0.6
NJ1435002	**Rockaway Township WD**	1.5	1.6	1.8	1.7	1.6	1.6
NJ1435003	USDOD Army Picatinny Arsenal	0.6	2.4	0.6	0.6	0.5	0.5
NJ1436002	Roxbury Water Company	0.9	1.2	1.1	1.0	1.0	0.9
NJ1436004	Roxbury Township WD - Skyview	0.0	0.8	0.0	0.0	0.0	0.0
NJ1439001	Wharton WD	1.4	2.4	1.3	1.3	1.2	1.1
NJ1918003	Sparta Township WU - Highlands	0.1	0.2	0.1	0.1	0.1	0.1
NJ2004002	NJ American Water - Raritan	98.0	178.6	78.7	75.0	72.4	69.0

Table H8. WMA06 PCWS 2050 Demands Projections (NJDEP Projections based on Van Abs et al., 2018)
*Red bold text indicates PCWSs in deficit in non-peak 2050 scenarios

Similar to WMA06 water supply service areas, expansion of both sewer and septic system use is limited in the region due to Highlands regulations. Highlights on WMA06 county sewer infrastructure are included below.

- **Morris County**: Major sewerage treatment plants in Morris County include Rockaway Valley Regional Sewerage Authority Sewage Treatment Plant, Morristown Sewer Utility Sewage Treatment Plant, Parsippany-Troy Hills STP, and Florham Park Sewerage Utility (Board of Chosen Freeholders of Morris County, 2014). As of 2019, Morris County had approximately 24 municipal and regional sewage treatment plants serving the county, although Morris County reported that several of their public sewer treatment facilities were at or near their maximum treatment limits (Tetra Tech, 2020a; Morris County Planning Board, 2013).
- **Essex County**: Since Essex County contains some of the oldest sewerage facilities in the state and most of its municipalities are at or near full build out, county wastewater planning efforts focus on replacing/improving existing wastewater infrastructure and modifying facilities to keep them viable. Existing wastewater facilities that serve WMA06 municipalities include Caldwell Borough STP and Livingston Township STP. In the county's 2014 Wastewater Management Plan, analysis of Essex County's sewer service areas and existing permitted capacity suggested that the county did not require extension to meet future wastewater needs. Residential, commercial, and industrial wastewater flows were not projected to significantly change through 2033, although a small amount of industrial flows were anticipated to shift to residential and commercial flows as abandoned industrial facilities are redeveloped as multi-purpose spaces (Hatch Mott McDonald, 2014).
- **Somerset County**: Somerset's sewerage facilities servicing WMA06 municipalities include Bernards Township Sewerage Authority's Harrison Brook STP, Bernardsville STP, and Warren Township Sewer Authority (Stage I, II, IV, and V). The county has reported that several of its domestic wastewater treatment plants, such as Harrison Brook STP and Warren Township Sewer Authority's Stage I, II, and V), may face deficit in the future and expansion may be necessary to accommodate growth (Somerset County Board of Chosen Freeholders et al., 2013; Somerset County Mitigation Planning Committee, 2019; Somerset County Planning Division, 2021).

8.1 RELATIONSHIP BETWEEN PROJECTED WATER USE AND DEMOGRAPHIC CHANGES

The findings from the 2050 water demands projections have some disagreement with the MPO and DOL population projections, primarily due to the disagreements between the MPO and DOL population projections discussed in Section 4. A problem with this comparison is that MPO projections are at the county and municipal level, while DOL projections are only at the county level; there is no way to know whether county-level differences result from WMA06 municipalities.

The MPO projects a population growth for Morris County of 27,931 people by 2050, and many of the PCWSs servicing Morris County locations are not expected to experience demand increases or supply deficit in 2050 (Similar findings were found for Somerset County, but since Somerset County WMA06 municipalities are only served by two major PCWSs, primary focus was placed on Morris County). However, Morris County's MPO projection for growth through 2035 is much smaller than the DOL projection (compare Morris County's MPO projection of a population growth of 13,023 people between 2020-2035 and DOL's projection of a population growth of 38,900 people between 2019-2034). While the 2050 demands projections identify some concern with several Morris County PCWSs (such as Denville Township WD, East Hanover Township WD, and Rockaway Township WD), there is some

uncertainty with these demand numbers, and Morris County PCWS 2050 projected demand may underestimate demands if the DOL projections are more accurate.

However, Essex County's MPO and DOL projections are opposite to those in Morris County in that MPO projections for Essex County are much higher than its respective DOL numbers. Essex County projects a 120,059 person population increase between 2020-2050 and a 56,472 person increase between 2020-2035, which is much larger than DOL's projection of Essex County to experience a population increase of 31,800 people between 2019-2034. The PCWS demands projections show some agreement with the MPO projections in showing projected deficits for North Caldwell WD and a potential concern for West Caldwell Township WD under peak demand scenarios. However, most projected 2050 demands scenarios for Essex County PCWSs provide little evidence for concern for meeting future water demand, with roughly half of the PCWSs projecting demand decline and several indicating demand may increase or decrease between the non-conservation and conservation scenarios.

Despite the uncertainty in population projections, several regional water demand trends may provide some buffer for the uncertainty. The overall declines in water demand over time may help to offset the effect of increased population growth in the region. Evidence of this was seen in the PCWS 2050 demand analysis as some areas with large projected population growth were not projected to experience demand increase or supply deficit, suggesting an offset between population growth and declining demand. Encouragement of conservation practices may also provide some buffer for uncertainty, as approximately a quarter of WMA06 PCWSs were projected to have demand decline only in their 2050 conservation scenarios. In addition, PCWSs can engage in strategies to improve their surplus/deficit including installation of new infrastructure, engaging in bulk transfer agreements with other PCWSs, making regulatory adjustments to change demand patterns, and identification of new water sources.

9. CLIMATE CHANGE ASSESSMENT

KEY FINDINGS

- Among the WMA06 counties, Morris County is projected to have the largest increase in precipitation across all storm events between 2020-2069.
- WMA06 groundwater recharge is currently higher than the statewide average. Groundwater recharge in WMA06 is projected to increase due to climate change and is not anticipated to pose an immediate threat to future groundwater availability.
- Streamflow in WMA06 is projected to continue to increase due to climate change, and very limited potential was detected for climate change to have adverse impacts on New Jersey surface water availability.
- It is critical to recognize that global and regional climate science is improving, allowing an evolving but better sense of climate change's effects on New Jersey water resources. As such these results need to be periodically reviewed as the data and models evolve.

9.1 GENERAL CLIMATE CHANGE PROJECTIONS FOR THE WMA06 REGION

Climate change in WMA06 is anticipated to follow state-wide trends for temperature and precipitation. Temperature and precipitation projections for 2050 are included below.

- **Temperature**: Statewide temperatures are projected to increase between 4.1 to 5.7 degrees Fahrenheit by 2050. Winters are anticipated to warm faster (compared to the other seasons), and summers are expected to become hotter.
- **Precipitation**: Overall, New Jersey is projected to receive 4% to 11% more precipitation by 2050. Larger rainfall events are anticipated to increase in frequency, and fall and spring seasons are projected to become wetter. Across the state, precipitation increases are anticipated to be higher in Northern New Jersey compared to southern and coastal areas (NJDEP, 2020).

	2-Year Storm	5-Year Storm	10-Year Storm	25-Year Storm	50-Year Storm	100-Year Storm
Essex	16%	17%	18%	22%	27%	32%
Morris	19%	21%	24%	30%	36%	43%
Somerset	17%	18%	21%	28%	35%	44%
Sussex	19%	19%	21%	24%	28%	33%
Union	17%	18%	19%	24%	29%	35%

Table H9. Projected Percent Increase for Precipitation among WMA06 Counties (Moderate RCP 4.5 Scenario for 2020-2069)

Table H9 shows the precipitation projections for WMA06 counties for different level storm events provided by the New Jersey Extreme Precipitation Projection Tool. These numbers reflect the upper likelihood for projected precipitation increases, representing a 17% chance that precipitation will increase more than the value shown. As shown in the table, Morris and Sussex counties are projected to have the largest precipitation increase for smaller storm events (two, five, and 10-year storm events), while Morris and Somerset are projected to have the largest precipitation increase for larger storm events (25, 50, and 100-year storms). Since Morris County is projected to have some of the largest increase in precipitation among New Jersey counties, WMA06 is projected to have some of the largest precipitation increase in the state (NJDEP, Northeast Regional Climate Center, & Cornell University, 2023).

9.2 POTENTIAL CHANGES TO WMA06 WATER AVAILABILITY DUE TO CLIMATE CHANGE

CHANGES TO GROUNDWATER RECHARGE

One potential impact of climate change on WMA06 is changes in groundwater recharge. Figure H10 provides forthcoming NJDEP analyses that show modeled average annual groundwater recharge in WMA06 and statewide between 1950 and 2020 using a 30-year rolling average and based on observed daily temperature and precipitation data. A 30-year rolling (or trailing) average – a common metric used to calculate climate parameters - was used to reflect the long-term changes in averages anticipated with climate change. For example, the estimated recharge for 1950 is the average of annual recharge data between 1921-1950. Between 1950 and 2020, the model indicates that average groundwater recharge in both WMA06 and statewide has increased over time. Between 1950 and 2000, WMA06 had a 30-year rolling average annual groundwater recharge of 10.8 inches, while between 2001-2020, WMA06's rolling annual groundwater recharge average increased to 11.3 inches. Statewide, the 30-year rolling average between 2001-2020 was 8.7 inches, which was higher than the average for 1950-2000 (8.0 inches).

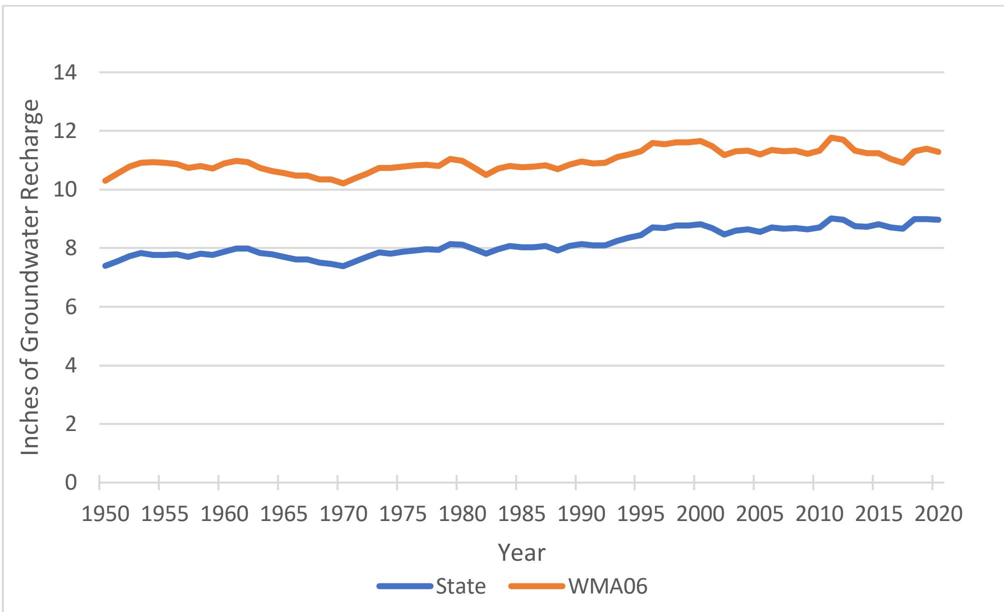


Figure H10. Comparison of Annual Groundwater Recharge in WMA06 and Statewide with a 30-Year Rolling Average (1950-2020)

WMA06 has also experienced larger annual groundwater recharge compared to the state average throughout the considered time period. For WMA06's rolling average recharge for 2001-2020, WMA06 received approximately 2.6 inches more of groundwater recharge annually compared to the state average. However, state average groundwater recharge has been increasing at a faster rate than in WMA06. As shown in Figure H11, between 1950-2000 and 2001-2020, the 30-year average annual groundwater recharge increased by approximately 0.8 inches statewide, compared to only 0.5 inches in WMA06.

NJDEP DWSG developed projections for state groundwater recharge under nine different climate scenarios (ensembles) for future temperature and precipitation. While only five of nine ensembles forecasted an increase in groundwater recharge from 2020 to 2050, all of the ensembles forecasted

more groundwater recharge in 2050 compared to 1980. These research findings suggest that future changes in groundwater recharge do not pose an immediate threat to future groundwater availability.

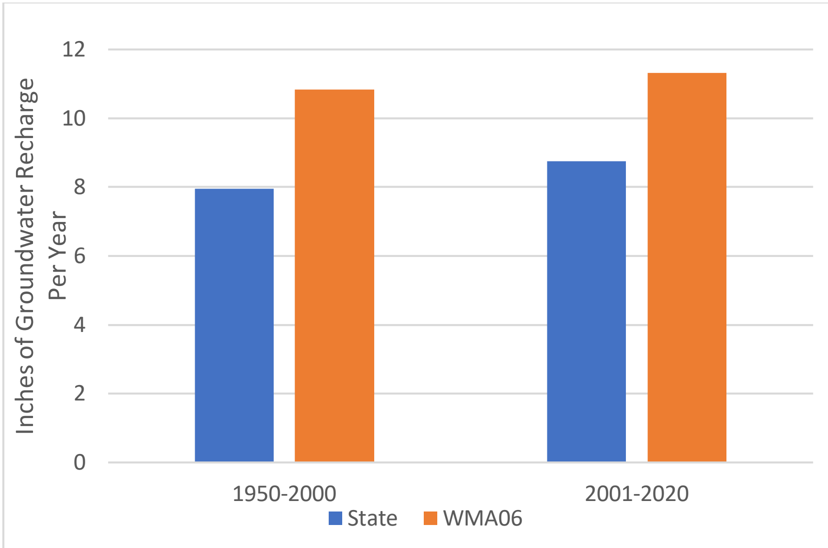


Figure H11. Comparison of Annual Groundwater Recharge Statewide and in WMA06 with a 30-Year Rolling Average (1950-2020)

CHANGES TO STREAMFLOW

NJDEP DWSG observed that streamflow in WMA06 has also increased, which is consistent with other climate change research. Figure H12 shows the annual estimated naturalized flows in WMA06 between 1951-2019 using a 30-year rolling average. Naturalized flows reflect the streamflow that would have occurred without the presence of the major surface water reservoirs or withdrawals. As shown in the figure, earlier in the time period considered (1951-1980), WMA06's 30-year rolling average flows were lower, with the lowest flows in 1970 (approximately 401 mgd). After 1970, rolling average streamflow in WMA06 gradually increased through 2019. From 1951-2000, WMA06's 30-year rolling average annual naturalized flows were approximately 440 mgd. Between 2001-2019, WMA06's 30-year rolling average annual naturalized flows increased to approximately 466 mgd, reflecting an approximately 6% increase.

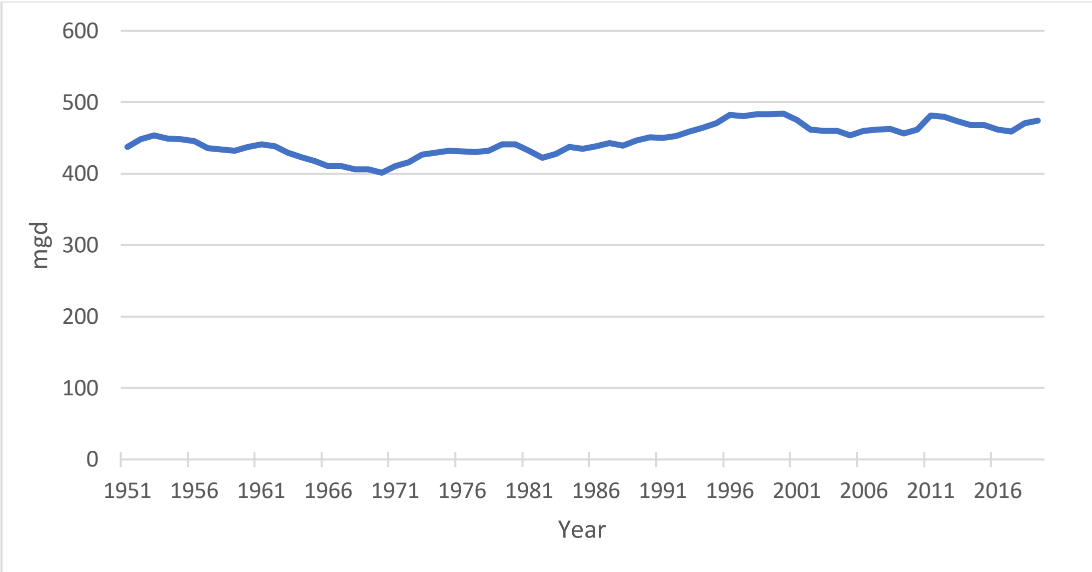


Figure H12. WMA06 Annual Naturalized Flows with a 30-Year Rolling Average (1951-2019)

The increase in streamflow in WMA06 is anticipated to continue in the future and reflects NJDEP DWSG's overall finding that more annual streamflow is anticipated statewide. Monthly trends are more variable, but more flow is expected in the fall and early winter; the greatest current stresses to water resources are generally in the summer through September, and so a shift in streamflow will have implications for summer stresses. From a water quantity perspective, the projection of increased streamflow is anticipated to be mostly beneficial to reservoirs, which will be discussed in the next sub-section.

CHANGES TO RESERVOIR SAFE YIELDS

A third potential impact of climate change is changes to a reservoir's safe yield. NJDEP examined the potential impacts of climate change to streamflow in reservoir systems. This research involved comparing scenarios of baseline existing operations to assumed climate change scenarios of reduced streamflow over the entire year and increased reservoir system drafts during the spring, summer, and fall seasons. The analysis altered the naturalized flows in order to compare them to the historic ones so that the range of observed variability could be reproduced under an assumed future climate scenario. WMA06's two reservoir systems (Jersey City Rockaway River System and New Jersey American Water Canoe Brook System), were similar to other Northeast New Jersey reservoir systems (such as Wanaque, Hackensack Reservoirs, DeForest Lake (New York), and Pequannock), in which there was very limited potential detected for climate change to have adverse impacts on New Jersey surface water availability. Combined usable storage across these systems during a repeat of the drought of record did not approach zero for any of the scenarios considered, and significant reserve storage was maintained overall. Note that this analysis assumed a simplified change to demand and streamflow and did not consider changes to raw water quality, which may impact a system's ability to treat to drinking water standards or address system resiliency or assessment management concerns. All of these items need to be continually addressed so that safe and reliable drinking water can be delivered to customers.

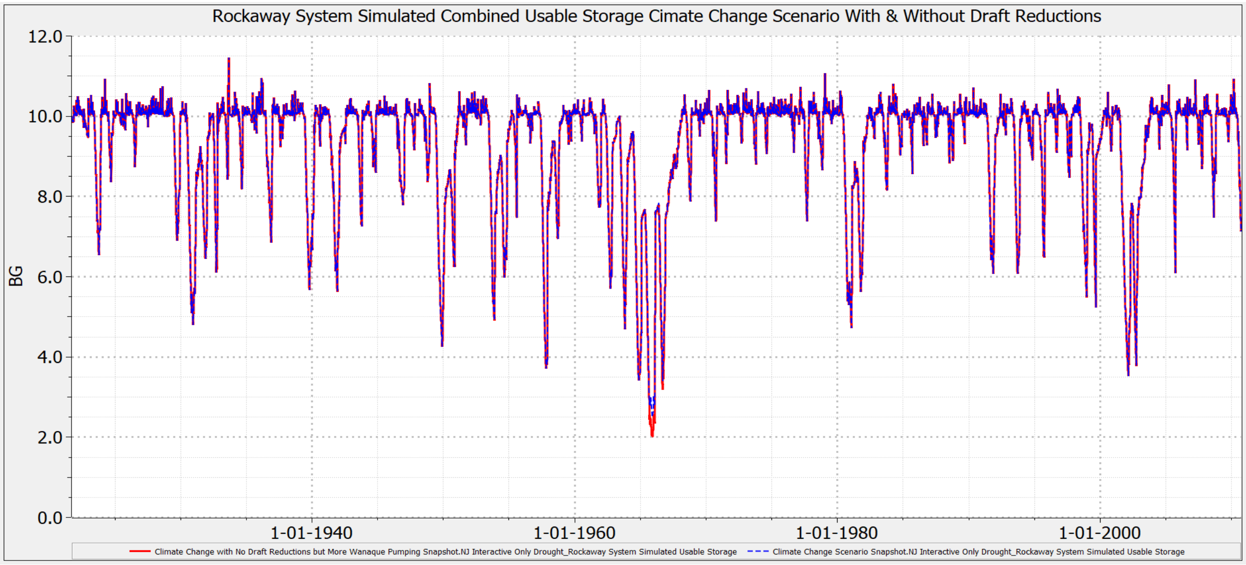


Figure H13. Rockaway System Simulated Combined Usable Storage Under Climate Change Scenario with and without Mandatory Draft Reductions

Figures H13 and 14 show the simulated combined usable storage for the period of 1930-2010 using the climate change scenarios. No significant impacts on water availability were found for the Jersey City Rockaway River System across all the scenarios considered. However, climate change was found to have a more significant impact on combined usable storage compared to scenarios that eliminated drought draft reductions. For the New Jersey American Water Canoe Brook System, none of the scenarios were found to have a significant impact on combined usable storage, and there were no significant impacts on water availability. However, as a pump storage system, pumpable flows were found to be increasing over time, especially in the fall and early winter.

Although it was found that climate change poses little threat of creating adverse impacts on New Jersey surface water availability, there are other unknown factors that may influence safe yield. As mentioned earlier in this sub-section, water quality changes may have a significant influence on safe yield and surface water availability, but it was not considered in the simulated study.

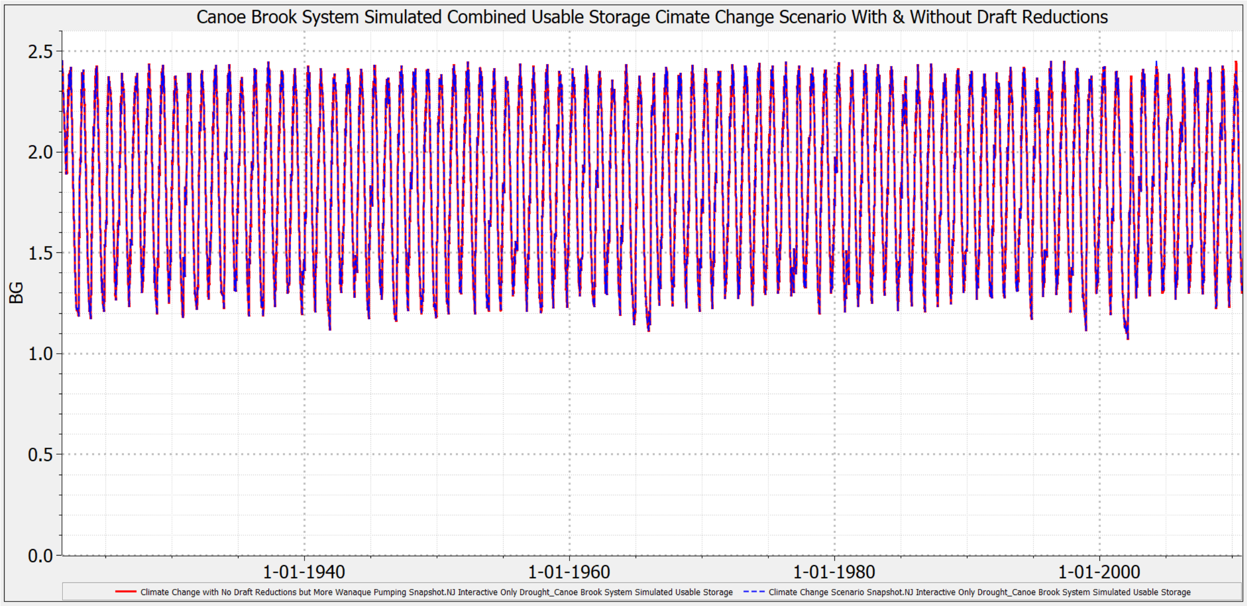


Figure H14. Canoe Brook System Simulated Combined Usable Storage Under Climate Change Scenarios with and without Mandatory Draft Reductions

10. POTENTIAL MANAGEMENT OPTIONS

Based on the findings from the assessment, WMA06 currently faces water supply vulnerability, which is heightened during periods of drought and has the risk of becoming more severe in the future despite increasing average rainfall and recharge volumes. Since there are only four HUC11s in WMA06, it was not very valuable to rank vulnerability on a HUC11 scale. Many of WMA06's municipalities are located within several different HUC11s, and HUC11 vulnerability differed when considering current and future water supply vulnerability (for example, some HUC11s were found to have more current water supply vulnerability, while others had higher risks for future water supply vulnerability). Included below are some major highlights from the assessment's findings for WMA06's HUC11s, along with some of the locations within the HUC11s found to be particularly vulnerable.

- **02030103010 (Passaic River Upr (above Pine Bk br))**: Current and potential future water supply vulnerability was detected as this HUC11 had the second largest LFM deficit in WMA06 during its three-year average in consumptive/depletive loss. It was also found to have the second largest average water withdrawals in WMA06 between 2016-2020. This HUC11 is serviced by several PCWSs that were found to have significant potable supply demand growth between 2011-2020 (West Caldwell WD, Chatham WD, East Hanover Township WD, Florham Park WD, Montville Township MUA), or were found to have demand increase or supply deficit in their 2050 demands projections (West Caldwell WD, East Hanover Township WD, North Caldwell WD). Since this HUC11 contains most of the Essex County WMA06 municipalities, the disagreement of the population forecasts for this county (along with Morris and Somerset counties) adds an additional level of uncertainty in projecting future water availability. Several areas within this HUC11 were found to be particularly vulnerable to face future water availability challenges.
    a. **Livingston Township, Millburn Township, and West Orange Township**: Although portions of these municipalities are located outside of WMA06, the populations of these three municipalities make up over 60% of the total population among WMA06's Essex County municipalities. All three of these municipalities also outperformed their 2020 MPO population forecasts, suggesting that population growth has been larger than originally projected. Among their PCWSs, Livingston Township DW had slight increases in potable supply demand between 2011-2020 (approximately 4%), while New Jersey American Water-Passaic experienced demand decline (approximately -16%). Although the 2050 demands projections found that New Jersey American Water-Passaic would experience demand decline, the uncertainty detected among the 2050 population projections makes this region an area to watch. All three of these municipalities contain socially vulnerable populations.
    b. **West Caldwell Township, North Caldwell Borough, and East Hanover Township:** These municipalities were selected due to being within the service areas of North Caldwell WD, West Caldwell WD, and East Hanover Township WD. North Caldwell WD faces current supply deficit and was projected to experience supply deficit in 2050. West Caldwell WD experienced a significant demand increase between 2011-2020 (approximately 36%) and was projected to be in deficit in some of its 2050 peak demand scenarios. West Caldwell Township is considered to be particularly vulnerable as it is serviced by both of these PCWSs and contains socially vulnerable populations. The municipalities serviced by West Caldwell WD are projected to grow by 2,001 people between 2020-2050. Almost all of East Hanover Township's population is serviced by East Hanover Township WD, and this municipality is anticipated to grow by

approximately 1,400 people between 2020-2050. East Hanover Township WD's service area is located in three HUC11s (02030103010, 02030103020, 02030103030). This PCWS was found to have one of the largest potable supply demand growths (approximately 31%) among major WMA06 PCWSs between 2011-2020 and was projected to face deficit in some of its 2050 demand scenarios.

- **02030103020 (Whippany River)**: This HUC11 faces current water supply vulnerability as it was found to have the largest LFM deficit in WMA06 during its three-year peak rolling average in consumptive/depletive loss. Although it was found to have the third highest five-year average water withdrawal in WMA06 between 2016-2020, it includes several PCWSs that experienced significant demand growth between 2011-2020 (Denville Township WD, East Hanover Township WD, Florham Park WD) or were found to have demand increase or supply deficit in their 2050 demands scenarios (Denville Township WD, East Hanover Township WD).
- **02030103030 (Rockaway River)**: This HUC11 was found to have the potential for future water availability vulnerability. Although this HUC11 was found to have the largest average water withdrawals between 2016-2020, it was found to have a net gain in the WMA06 LFM analysis due to the discharge of treated wastewater from other HUC11s (primarily the Whippany River watershed) at the base of the watershed. However, this HUC11 contains several PCWSs that were found to face either current or future challenges with meeting potable water demand. This HUC11 is serviced by several PCWSs that were found to have significant potable supply demand growth between 2011-2020 (Denville Township WD, East Hanover Township WD, Jefferson Township WU- Lake Hopatcong, Fayson Lakes WC, Montville Township MUA, Mount Arlington Borough DWP Main, Rockaway Township WD, Sparta Township WU- Highlands) or were found to have demand increase or supply deficit in their 2050 demands scenarios (Denville Township WD, East Hanover Township WD, Jefferson Township WU- Lake Hopatcong, Fayson Lakes WC, Rockaway Township WD, Roxbury Water Company). This HUC11 is also where significant water withdrawals are exported out of WMA06 for use in Jersey City and its customer municipalities. Therefore, the HUC11 has both depletive water use and imported water. Two areas within this HUC11 were found to be particularly vulnerable to face future water availability challenges.
    a. **Rockaway Township and Denville Township**: These municipalities were selected since they are serviced by several PCWSs projected to potentially experience water supply deficit. Rockaway Township was found to be particularly vulnerable since two of its PCWSs show signs of potential future water supply deficit (Denville Township WD and Rockaway Township WD). Rockaway Township is projected to grow by 2,111 people between 2020-2050 and also contains socially vulnerable populations. Denville Township (which also is within the Whippany River watershed) was selected as it contains a significant population serviced by Denville Township WD. The service area of Denville Township WD includes municipalities containing socially vulnerable populations, including Parsippany-Troy Hills Township (a focus municipality) and Randolph Township. Denville Township WD is projected to experience deficit in some of its peak 2050 demands projections, but many of the municipalities in its service area do not have large populations serviced by this PCWS. However, the majority of Denville Township's population is serviced by Denville Township WD, and it is considered their primary PCWS.

10.1 MANAGEMENT OPTIONS

Discussed below are potential management options for the WMA06 region. These options are designed to include both strategies that can be recommended across WMA06 and more focused strategies that

can address specific localized needs. While only a few areas were highlighted in the region, these management options can be implemented in similar regional locations facing similar challenges. This section is designed to serve as a flexible blueprint for management options since each area will differ on strategies that best address their individual water supply challenges and should be monitored closely and updated as new research and data become available.

The first management option, updating regional groundwater modeling, is recommended for the entire WMA06 region. Although this region has been a validated area of concern for water availability since the 1980s (Hoffman, 1989; Nicholson et al., 1996), updates to modeling can consider changes to the region (such as population growth, changing water demands, and land use trends) and more recent scientific understanding of the interaction between aquifer underlying bedrock and more-productive unconsolidated units. Earlier modeling efforts, such as those discussed in Hoffman, 2012, made several recommendations for future regional modeling, including: (a) recalibrating modeling to consider data from sources such as field investigations to increase model accuracy, and (b) the development of new modeling that can better account for relationships between aquifers, recharge areas, and discharge areas, and how pumping is regionally distributed. Incorporation of these changes along with additional updates may help provide a more comprehensive understanding of regional water availability.

The second management option, use of a water fee or surcharge on end users of Highlands water for the purposes of preserving lands important to water resources, has been suggested to address the local land use impacts of Highlands regulations that protect water withdrawals exported outside of the Highlands Region. Highlands residents face significant land use restrictions which are designed to protect regional water resources (Highlands Council, 2008b). A fee or surcharge can serve the dual purpose of compensating residents for the restrictions they face and also encourage water conservation among end users. This management option could also be especially beneficial for assisting socially vulnerable communities located within the Highlands since their ability to promote economic development may be limited due to Highlands regulations. Previous legislation on this option (Assembly Bills A2234 and A2603) were proposed in the 2010-2011 New Jersey Legislative Session (Morris County Planning Board, 2013).

The third management option, protection of aquifer recharge areas, also includes protection of regional wetlands and opportunities for flood management. As mentioned earlier in this assessment, WMA06 suffers from significant riverine flooding, particularly along the Rockaway, Whippany, and Passaic rivers (Union County, 2016; Tetra Tech, 2020a; New Providence Open Space Advisory Board, 2006; Morris County Planning Board, 2000; Dewberry-Goodkind, Inc., 2006; Jonathan Rose Companies et al., 2014). Protection of aquifer recharge areas can help the regional water system and mitigate flooding by providing more permeable open space for water to enter the aquifer system. Options to encourage protection of aquifer recharge areas can include:

- **Further efforts to delineate groundwater recharge areas:** The Highlands Council has delineated groundwater recharge areas in the region, using modeling techniques from NJDEP. However, as of 2018, it was reported that there were no groundwater recharge areas delineated for Essex County (Livingston Planning Department, 2018). Re-evaluation and periodic updating of groundwater recharge areas may be effective in WMA06, particularly since WMA06's Essex County municipalities are less populated compared to some of the larger urban areas located outside the region. The same issue applies to the Union and Somerset County portions of WMA06.
- **Coordinating aquifer recharge area protection with existing land conservation and planning efforts**: New Jersey is active in acquiring open space properties for environmental purposes. Coordination with existing programs, such as NJDEP's Green Acres and Blue Acres programs, can assist WMA06 county and municipal efforts to prioritize the purchase of open space in recharge

areas (NJDEP, 2022; NJDEP, 2023). The Highlands Regional Master Plan also requires protection of major aquifer recharge areas in the Preservation Area and conforming Planning Area municipalities (Highlands Council, 2008b). In addition, aquifer recharge area protection can build off of localized land conservation and planning programs. For example, Livingston Township has its program to acquire land rights for conservation purposes outlined in its 2018 Master Plan. While this approach may face challenges from lack of sufficient funding, streamlining access to grants and partnerships with other conservation organizations may help to prioritize purchases of properties where potential for aquifer recharge is the highest, such as wetlands (Livingston Planning Department, 2018). Another example is Union County, which has prioritized land use planning to provide open space parkland in flood-prone areas to minimize riverine flood risk. This type of program could potentially be expanded to consider aquifer recharge potential when selecting areas for open space parkland (Union County, 2016).

The final management option, <u>further assessment of WMA06 PCWSs to meet future regional water demand,</u> is recommended for the entire WMA06 region, especially for the identified vulnerable PCWSs. As was found in Section 8, although WMA06's PCWSs are anticipated overall to experience less demand in 2050 compared to current demand numbers, several PCWSs were projected to experience either demand increase or supply deficit in 2050. This presents some concern with meeting future water demands. Planning efforts can be made to further assess WMA06 PCWS potential management options and their feasibility for meeting future demands if they run into deficit (such as identification of alternative water sources, bulk transfers from other PCWSs, existing infrastructure for interconnections between PCWSs, etc.). This assessment can build from earlier NJDEP PCWS research, such as the 2007 NJDEP Interconnection Study (NJDEP et al., 2007). Specific focus can be placed on identifying PCWSs that are most isolated (in terms of connecting to other PCWSs and their purveyor service areas) and contain socially vulnerable populations in their service areas. Collaboration with PCWSs can strongly assist in these efforts and provide early identification of potential problems for PCWSs to respond to deficit, which may help to streamline regional response to deficit if it occurs in the future.

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State of New Jersey

Department of Environmental Protection

2024 NEW JERSEY STATEWIDE WATER SUPPLY PLAN

APPENDIX I

AN ASSESSMENT OF REGIONAL WATER AVAILABILITY AND DEMAND FOR WATERSHED MANAGEMENT AREA (WMA) 13: BARNEGAT BAY WATERSHEDS

Draft for Public Comment

AN ASSESSMENT OF REGIONAL WATER AVAILABILITY AND DEMAND FOR WATERSHED MANAGEMENT AREA (WMA) 13: BARNEGAT BAY WATERSHEDS

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May 2023

Table of Contents

EXECUTIVE SUMMARY

Water Management Area (WMA) 13 is located in central eastern New Jersey, within the Atlantic Coastal Region. It encompasses all of Ocean County and portions of municipalities in Burlington and Monmouth County. WMA 13 is comprised of 15 HUC11 watersheds that flow into Barnegat Bay. The Metedeconk River, Toms River, Forked Rivers, and Cedar Creek are significant surface waters in WMA 13.

WMA 13 is experiencing some of the fastest population growth in the state, and this report conducts a population analysis of the area. The report designates six municipalities as areas of focus due to their significant population changes. These municipalities are Barnegat Township, Brick Township, Berkeley Township, Lakewood Township, Jackson Township, and Toms River Township.

The report explores WMA 13 and the municipalities of focus through the analysis of social vulnerability, land use trends, water availability and demand projections, water utilities and infrastructure, and climate change projections. Future water demand is projected through 2050.

Water withdrawals in WMA13 primarily occur in HUC11 watersheds 02040301080 (Toms River, below Oak Ridge Parkway), 02040301040 (Metedeconk River), and 02040301130 (Lower Little Egg Harbor Tributary). However, according to estimates from the Low Flow Margin, the HUC11 watersheds that are most stressed include 02040301050 (Kettle Creek / Barnegat Bay North), 02040301060 (Toms River, above Oak Ridge Parkway), and 02040301080 (Toms River, below Oak Ridge Parkway).

Water quality is a significant concern for WMA13, with 32 impaired water designations as defined by the New Jersey's 303(d) since 2012. The analysis of these pollutants has determined that stormwater is the primary source of these impairments.

The planning period for this report is 2020-2050, and policy recommendations are listed as strategies to reduce the region's water supply vulnerabilities. These policy recommendations include higher density residential development and stormwater utility fees to raise revenues to mitigate the region's stormwater runoff.

1. INTRODUCTION

The Barnegat Bay Watershed is designated by the NJDEP as Watershed Management Area (WMA) 13. WMA13 is located in central eastern New Jersey, in the Atlantic Coastal Region (see Figure I1). WMA 13 includes all of Ocean County and portions of municipalities in Burlington and Monmouth County. The total area of WMA 13 is over 508,000 acres.

The coastal and ecological features of WMA 13 are distinctive which draws thousands of visitors throughout the year, especially during the summer months. WMA 13's coastline begins at the Point Pleasant Canal and ends at the Little Egg Harbor Inlet. The Metedeconk River has immediate impacts on the ecological health of the Barnegat Bay Estuary (Metedeconk River Watershed Plan, 2017). WMA 13 is an important estuary ecosystem for various species.

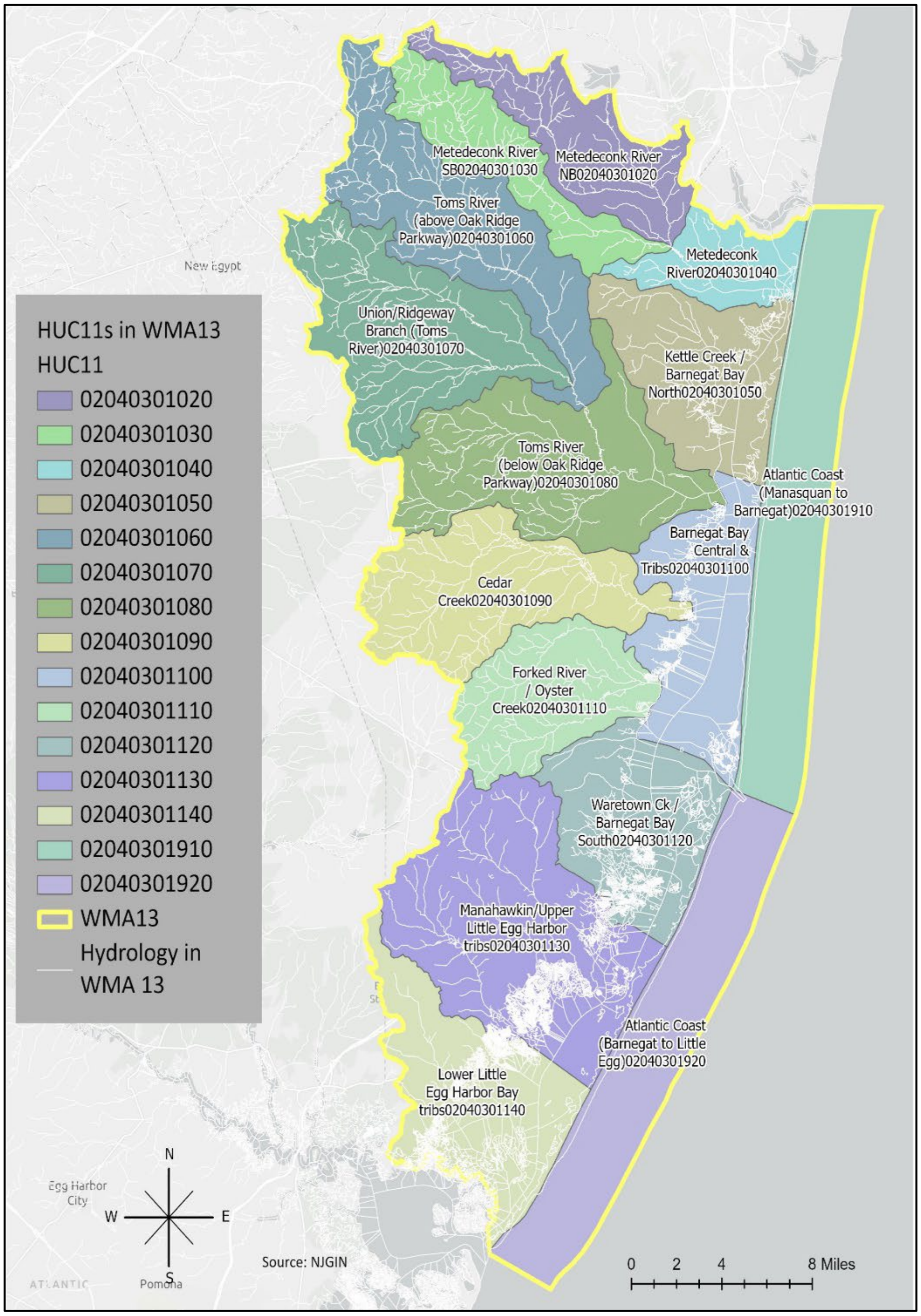

Figure I1. HUC11 Map of WMA 13

The watershed's water resources provide immense economic value to WMA 13. Economic value is extracted from WMA 13's water resources and habitats, ecosystem goods and services, and watershed related employment (Kauffman & Curz-Ortíz, 2012). In 2012, the watershed was estimated to contribute $2 to $4 billion annually to the state's economy (Kauffman & Curz-Ortíz, 2012).

The protection of the health of the watershed is vital for the future of the region, not only for preserving its natural ecosystems and wildlife but also for ensuring the sustainability of recreational activities in the area. As a result of development patterns in WMA 13, the ecological health of the watershed has declined. To mitigate the impact of development on water supplies and the ecological health of the area, NJDEP enforced regulations that protect waterways and reduce development in protected areas. Regulations include the following: the Coastal Area Facilities Review Act (CAFRA), water supply critical areas, category one waterways designation, and the Pinelands Protection Act of 1979.

1.1 GOALS

This report aims to characterize WMA 13 as it relates to its water supplies and suggests policies to make WMA 13 water supplies more resilient. This report examines current water availability and demands and uses projections for future water availability and demands. The planning period for this report is 2020-2050. Following these findings, policy recommendations are listed as strategies to reduce the region’s water supply vulnerabilities.

2. METHODOLOGY

In short, this paper aims to characterize the current and future water supply conditions, and present regional specific policy recommendations. Understanding the watershed requires an analysis that explores multiple scopes of analysis (at the watershed, county, and municipality level of analysis).

2.1 DEMOGRAPHIC ANALYSIS

To understand WMA 13's water demands, a demographic analysis was performed. This analysis identified communities that could be vulnerable to water stress. This involved a deep dive of population trends in WMA 13 and the land use changes. This report focuses on a planning period for 2020-2050 and explores the data at a county and municipality level of analysis. Population data was obtained from the 2020 U.S Census Bureau. Population projections were developed by two Metropolitan Planning Organizations in the region: New Jersey Transportation Planning Authority (NJTPA) and the Delaware Valley Regional Planning Commission (DVRPC). NJTPA's geographic area of analysis included most of WMA 13, except for municipalities in Burlington County. DVRPC's data analyzed Burlington County municipalities.

One of the first steps in understanding WMA 13's water demand was a descriptive analysis of the population count at the county and municipal level. Examining population projections at the county-level of analysis was the first step in identifying regions within WMA 13 that were experiencing population changes. To learn more, the level of analysis was focused on WMA 13's municipalities. Municipalities that experienced extensive population changes were identified as municipalities of focus for this report.

Following an evaluation of population trends between 2020-2050 in WMA 13, a socioeconomic analysis was conducted to identify vulnerable populations in the region and factors contributing to their vulnerability. These findings were then used to develop policy recommendations that consider the unique challenges faced by these vulnerable groups. Social vulnerability in the region was explored using the CDC's Social Vulnerability Index (SVI) Tool and New Jersey's definition of an overburdened community (OBC) as defined by the 2021 New Jersey Environmental Law. SVI examines the relative vulnerability of each U.S Census tract in the watershed (CDC SVI Documentation, 2020). New Jersey's definition of an OBC requires that any census block group meets at least one of the following definitions:

1. at least 35 percent of the households qualify as low-income households (at or below twice the poverty threshold as determined by the United States Census Bureau);
2. at least 40 percent of the residents identify as a minority or as members of a State recognized tribal community; or
3. at least 40 percent of the households have limited English proficiency (without an adult that speaks English "very well" according to the United States Census Bureau).

(Source: NJDEP, 2021)

The final step in the demographic analysis was examining land use changes in the watershed from 2012 and 2015. Land use changes are one of the primary indicators of a watershed's water supply experiencing stress. Data for land use/land cover was obtained from NJDEP's GIS Data. Priorities and presentation strategies of publicly owned land and other important resources were obtained from

Ocean County's 2020 Open Space, Parks, and Recreation Plan and the 2021 Comprehensive Conservation and Management Plan for the Barnegat Bay-Little Egg Harbor Estuary.

2.2 WATER AVAILABILITY AND DEMAND ANALYSIS

WMA 13's water availability and water demand were analyzed by exploring water quantity data, water quality reports, and the physical water infrastructure available.

Water quantity was examined with NJDEP's data for withdrawal and discharge at the HUC11 level of analysis. This report focused on data from 1990-2020 for withdrawal trends by source group and use type from 1990-2020. Discharge data was explored by its source for the same period. Finally, the five-year average of water withdrawals from each HUC11 in WMA 13 was analyzed.

Water quality was evaluated using New Jersey's 2016 Integrated Water Quality Assessment Report for the Barnegat Bay watershed, NJDEP Metedeconk River Watershed Protection Plan for WMA 13 and Brick Township Municipal Utilities Authority (BTMUA) Metedeconk River Watershed Protection Plan.

Water infrastructure in WMA 13 was characterized using GIS analysis of public community water systems (PCWS).

2.3 CLIMATE CHANGE AND SEA LEVEL RISE ASSESSMENT

Climate change's threats to WMA13's water supplies were quantitatively assessed through the use of sea level rise and assessment of water supply infrastructure. Climate change as it relates to water supplies was examined through the following: sea level rise and its impact on withdrawal and discharge sites in WMA 13, PCWS service areas routinely flooded by 2ft and 5ft of sea level rise, and overburdened routinely flooded by 2ft and 5ft of sea level rise. Data for withdrawal and discharge sites for 2016-2020 was provided by NJDEP. Sea level rise estimates come from NOAA's Sea level Rise Viewer, which represents the mean higher water conditions: the average of the higher of the daily high tides over the National Tidal Datum Epoch (1983-2001) (NOAA Sea level Rise Viewer, 2022). PCWS service areas were obtained from NJDEP's publicly available GIS data. The overburdened community data came from NJDEP's publicly available data sheet.

2.4 DEVELOPMENT OF DRAFT POLICY OPTIONS

To develop policy recommendations for WMA 13, information from the water quantity and demand analysis and the vulnerable community assessment was used to determine specific areas of focus.

3. WMA 13 WATERBODIES

3.1 SURFACE WATER SURFACES

WMA 13 is comprised of 15 HUC11 watersheds that flow into the Barnegat Bay (see Figure I1). The Metedeconk River, Toms River, Forked Rivers, and Cedar Creek are significant surface waters in WMA13 (NJDEP WSP, 2017). Another component of the watershed's water availability is its surface water reservoirs. WMA 13's major surface water supply reservoir is the Brick Township reservoir, whose source is the Metedeconk River. The reservoir is owned by Brick Township MUA and has 0.9 bg of usable storage.

Surface water is stored in reservoirs during abundant streamflow conditions and withdrawn during drier conditions. These surface-water reservoirs have a defined safe yield, which limits the amount of water that can be withdrawn. NJDEP defines safe yield as, "the maintainable yield of water from a surface or ground water source or sources which is available continuously during projected future conditions, including a repetition of the most severe drought, without creating undesirable effects"(p.2) (N.J.S.A 58:1A).

The Metedeconk River watershed is 90-square miles and drains into the northern portion of the Barnegat Bay. The Metedeconk River flows through parts of Monmouth and Ocean County, eventually emptying into the bay. The river has a North and South Branch; they converge at the Forge Pond in Brick Township. The Metedeconk River is a resource for the region's drinking water supply (Metedeconk River Watershed Plan, 2017).This led to its designation as a Category One (C1) Waterway.

The Toms River watershed is 124 square miles, is composed of small tributaries, and drains into the bay. Toms River flows southeast through the western Ocean County, through parts of the New Jersey Pinelands, eventually emptying into the Barnegat Bay. Toms River watershed includes residential areas and the New Jersey Pinelands, which are protected. Toms River and its tributaries are designated as C1 waterways.

Cedar Creek watershed is 54.3 square miles, flows eastward along the southern portion of Berkeley Township and drains into the bay. The subwatershed is almost entirely within the Pinelands National Reserve, which is mostly forested (89%) (Barnegat Bay Partnership, 2021).

The Forked River subwatershed is 26 square miles (Ocean County, 2016). The Forked River has three branches: North Branch (16.8 square miles), the Middle Branch (4.9 square miles), and the South Branch (4.3 square miles). Portions of this subwatershed are in the New Jersey Pinelands, with more forested areas, and areas protected for species and recreational enjoyment. A section of the Edwin B. Forsythe National Wildlife Refuge is in Middle Branch of the Forked River. The eastern portion of the North Branch is residentially and commercially developed.

HUC11	HUC 11 Name	HUC 11 Area (mi²)	Watershed Area (mi²)	Pinelands	Critical Area	Municipalities in Ocean County (except where noted)
02040301020	Metedeconk River NB	38	38		Partial	Brick Township, Freehold Township (Monmouth County), Howell Township, Jackson Township, Lakewood Township, Millstone Township (Monmouth County), Wall Township
02040301030	Metedeconk River SB	31	31		Partial	Brick Township, Freehold Township (Monmouth County), Jackson Township, Lakewood Township, Millstone Township (Monmouth County)
02040301040	Metedeconk River	20	89		All	Bay Head Borough, Brick Township, Lakewood Township, Mantoloking Borough, Point Pleasant Borough, Point Pleasant Beach Borough
02040301050	Kettle Creek / Barnegat Bay North	31	31		All	Berkeley Township, Brick Township, Island Heights Borough, Lavallette Borough, Mantoloking Borough Lakewood Township, Seaside Heights, Toms River Township
02040301060	Toms River (above Oak Ridge Parkway)	60	123	Partial	Partial	Freehold Township (Monmouth County), Jackson Township, Lakewood Township, Manchester Township, Millstone Township, Toms River
02040301070	Union/Ridgeway Branch (Toms River)	63	63	Partial	Partial	Jackson Township, Lakehurst Borough, Manchester Township, Plumsted Township, Toms River Township
02040301080	Toms River (below Oak Ridge Parkway)	68	191	Partial	All	Beachwood Borough, Berkeley Township, Island Heights Borough, Lacey Township, Manchester Township, Ocean Gate Borough, Pine Beach Borough, South Toms River Borough, Toms River Township
02040301090	Cedar Creek	68	68	Partial	Partial	Berkeley Township, Lacey Township, Manchester Township, Ocean Township
02040301100	Barnegat Bay Central & Tribs	46	468		Partial	Barnegat Light Borough, Berkeley Township, Lacey Township, Ocean Gate Borough, Ocean Township, Seaside Heights Borough, Seaside Park Borough, Toms River Township
02040301110	Forked River / Oyster Creek	39	39	Partial	Partial	Barnegat Township, Lacey Township, Ocean Township
02040301120	Waretown Ck / Barnegat Bay South	25	25	Partial		Barnegat Light Borough, Barnegat Township, Harvey Cedars Borough, Long Beach Township, Ocean Township, Stafford Township

HUC11	HUC 11 Name	HUC 11 Area (mi^2)	Watershed Area (mi^2)	Pinelands	Critical Area	Municipalities in Ocean County (except where noted)
02040301130	Manahawkin/ Upper Little Egg Harbor Tribs	72	72	Partial		Barnegat Township, Bass River Township, Eagleswood Township, Little Egg Harbor Township, Long Beach Township, Ocean Township, Ship Bottom Borough, Stafford Township, Surf City Borough
02040301140	Lower Little Egg Harbor Bay Tribs	35	35	Partial		Bass River Township, Beach Borough, Eagleswood Township, Little Egg Harbor Township, Long Beach Township, Tuckerton Borough
02040301910	Atlantic Coast (Manasquan to Barnegat)	139	139		Partial	Barnegat Light Borough, Bay Head Borough, Berkeley Township, Lavallette Borough, Manasquan Borough, Ocean Township, Point Pleasant Beach, Seaside Heights Borough, Seaside Park Borough, Toms River Township
02040301920	Atlantic Coast (Barnegat to Little Egg)	122	122			Barnegat Light Borough, Beach Haven Borough, Berkeley Township, Harvey Cedars Borough, Long Beach Township, Ship Bottom Borough, Surf City Borough

Table I1. HUC11 Information for WMA13 (Source: GIS Analysis Performed using Data from NJDEP & NJGIN, 2023)

3.2 GROUNDWATER SOURCES

The primary source of groundwater in this watershed management area is the Kirkwood-Cohansey aquifer system. The Kirkwood-Cohansey aquifer is an unconfined aquifer that supplies water throughout the Outer Coastal Plain of southern New Jersey. This is the major unconfined aquifer in the area. The aquifer supplies freshwater also to Barnegat Bay, directly and by contributing to stream flow. There are seven confined aquifers underneath the Kirkwood-Cohansey system. In addition to the Kirkwood-Cohansey system, water purveyors in Ocean County use the Potomac-Raritan-Magothy (PRM) system; it is the second most used source of groundwater in the county (Ocean County, 2011). Other aquifers in the watershed used less often include the Englishtown, Wenonah-Mt. Laurel, Vincentown, Piney Point, and the Atlantic City 800 Foot Sand (Ocean County, 2011).

4. DEMOGRAPHIC ANALYSIS

KEY FINDINGS

- Every county in WMA 13 population grew between 2010-2020. Ocean County increased its total population by 10.5% from 2010-2020, which makes it the 2nd fastest growing county in New Jersey (U.S Census Bureau, 2020).
- Counties in WMA 13 are growing faster than MPO projections. Ocean County population was larger than NJTPA's estimates by 6.4% percent. Monmouth County population was 2.1% larger than NJTPA's estimates. Burlington County's population was 2.9% larger than DVRPC estimates.
- There are municipalities in WMA 13 experiencing significant changes in their population growth. The municipalities of focus are the following: Barnegat Township, Berkeley Township, Brick Township, Jackson Township, Lakewood Township, and Toms River Township.

4.1 POPULATION ANALYSIS AND INTRODUCTION TO FOCUS MUNICIPALITIES

To analyze the population of WMA 13, data from the 2020 Census and population projections from NJTPA and DVRPC were used. First, the 2020 census population for each county and municipality in WMA 13 was explored. Next, the population projections for 2020 at both the county and municipality levels were compared to 2020 Census populations. The population projections from NJTPA and DVRPC were published before the 2020 Census was released. There was variability between actual and projected populations for the region, which was factored in the analysis. The analysis identified municipalities in WMA 13 that experienced population growth or decline, which designated them as municipalities of focus.

COUNTY-WIDE ANALYSIS

Table I2 lists Census population data for WMA 13. On par with state trends, every county in WMA 13 experienced population growth. In WMA 13, Ocean County grew the most, a 10.5% increase in its census population between 2010-2020. Burlington and Monmouth counties grew modestly between 2010-2020.

County	2020 Census Population	Percent Change 2010-2020
Burlington	461,860	3
Monmouth	643,615	2
Ocean	637,229	11
New Jersey	9,288,994	6

Table I2. Census Data for Counties in WMA 13
(Source: U.S Census Bureau, 2020)

Table I3 shows economic and household demographic information for counties in WMA13, relative to the state (indicated in red). Despite having the largest population growth in the county, Ocean County's economic characteristics fall below state averages. Ocean County has the highest poverty rate at 11.4% and the lowest median household income of counties in WMA13, at $72,679. This is lower than the state's average by $12,566 dollars.

Area	Burlington County	Monmouth County	Ocean County	New Jersey
2010 Census Population	448,734	630,380	576,567	**8,791,894**
2020 Census Population	461,860	643,615	637,229	**9,288,994**
Median Household Income (2020)	$90,329	$103,523	$72,679	**$85,245**
Poverty Rate	8%	7%	11%	**10%**
Unemployment Rate (NJ BLS)	5%	6%	6%	**6%**
2020 Population Density (per mi^2)	578	1,375	1,1014	**1,263**
2020 Real GDP Per Capita	$44,735	$53,886	$37,041	**$44,153**
2020 Real GDP (Billions of Dollars)	25,828	32,246	19,318	**535,324**

Table I3. WMA 13 County Demographics Sources: Unemployment Rate: NJ Department of Labor and Workforce Development: Labor Force Estimates (2022), 2020 U.S Census Bureau, 2020 5-Year Estimate (American Community Survey, 2022), GDP by County, (Bureau of Economic Analysis, 2022)

MUNICIPALITY-WIDE ANALYSIS

Similar to trends at the county level, municipalities in Ocean County experienced significant changes in their population between 2010-2020. WMA 13 municipalities in Burlington and Monmouth County experienced modest population changes. This report focuses on municipalities that experienced significant population changes between 2010-2020. Table I4 lists the municipalities of focus in this report as indicated in orange shading.

Municipality	County	2020 Census Population	Percent Change 2010-2020 (%)
Barnegat Light Borough	OCEAN	640	11.5
Barnegat Township	OCEAN	24,296	16.0
Bass River Township	BURLINGTON	1,355	-6.1
Bay Head Borough	OCEAN	10,859	-1.7
Beach Haven Borough	OCEAN	24,296	16.0
Beachwood Borough	OCEAN	10,859	-1.7
Berkeley Township	OCEAN	43,754	6.1
Brick Township	OCEAN	73,620	-1.9
Eagleswood Township	OCEAN	1,722	7.4
Freehold Township	MONMOUTH	35,369	-2.3
Harvey Cedars Borough	OCEAN	391	16.0

Municipality	County	2020 Census Population	Percent Change 2010-2020 (%)
Howell Township	MONMOUTH	53,537	4.8
Island Heights Borough	OCEAN	1,650	-1.4
Jackson Township	OCEAN	58,544	6.7
Lakewood Township	OCEAN	135,158	45.6
Lavallette Borough	OCEAN	1,787	-4.7
Manchester Township	OCEAN	45,115	4.7
Mantoloking Borough	OCEAN	331	11.8
Millstone Township	MONMOUTH	10,376	-1.8
Ocean Gate Borough	OCEAN	1,932	-3.9
Ocean Township	OCEAN	8,835	6.0
Plumsted Township	OCEAN	8,072	-4.1
Seaside Heights Borough	OCEAN	2,440	-15.5
Seaside Park Borough	OCEAN	1,436	-9.1
Ship Bottom Borough	OCEAN	1,098	-5.0
South Toms River Borough	OCEAN	3,643	-1.1
Stafford Township	OCEAN	28,617	7.8
Toms River Township	OCEAN	95,438	4.6
Tuckerton Borough	OCEAN	3,577	6.9

Table I4. Census Data for Municipalities in WMA 13 (Source: U.S Census Bureau, 2020)

Quick Facts about the Municipalities of Focus

- Barnegat Township is a suburban, coastal community in Ocean County.
- Berkeley Township is an established suburban community in Ocean County; it has some area along the Jersey Shore.
- Brick Township is an established suburban, partially shore-based community in Ocean County that has a limited amount of vacant land available for development.
- Jackson Township is an established suburban, interior community in Ocean County that began growing in the 1970s (Jackson Township, 2009).
- Lakewood Township is a rapidly growing interior community in Ocean County.
- Toms River Township is a suburban, coastal community in Ocean County.

PROJECTION ANALYSIS

Several planning agencies created county population forecasts for counties and municipalities in New Jersey prior to the 2020 Census data release. Burlington County, Monmouth County, and Ocean County exceeded 2019 New Jersey Department of Labor (DOL) population projections with their 2020 Census population. Burlington County and Ocean County grew so much that they've already exceeded New Jersey DOL's projection estimates for 2024. 2020 Census populations exceed every county projection

forecasted by DVRPC and NJTPA. Population projections indicate that these three counties will continue to grow throughout the planning period. Ocean County is expected to grow the most out of the three counties. In 2020, the percentage difference between NJTPA's 2020 forecast and its 2020 Census population was 6.43%. By 2050, NJTPA estimates that Ocean County's population will increase by 100,000 people, making it the largest county in WMA 13.

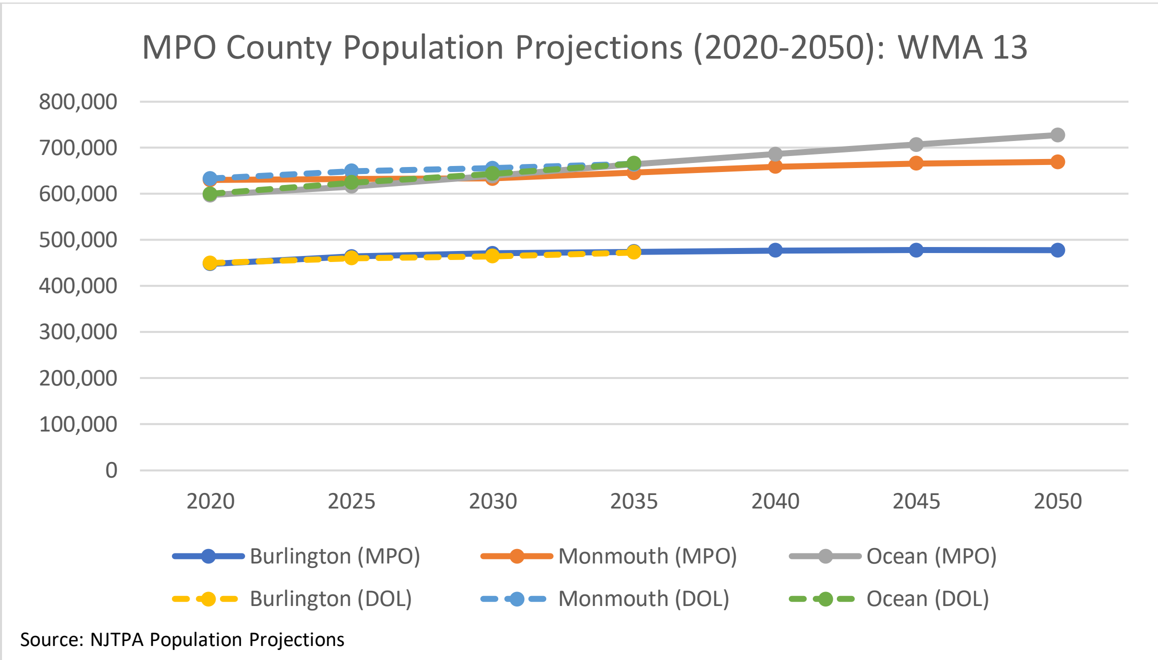

Figure I2. NJ DOL & MPO Population Projections for WMA 13 (Source: NJTPA & NJ DOL)

NJTPA 2020 population were analyzed to support the methodology for determining municipalities of foucs. Figure I3 demonstrates the percent differences between the 2020 Census population and the 2020 NJTPA of municipalities designated as municipalities of focus. Municipalities with signficant percent change differences from the 2010-2020 Census also had signficant percent differences between their 2020 census populations and 2020 NJTPA projections. This supports the decision to make these six municpalities focus areas. Figure I4 shows projected population growth from 2020-2050 in each municipality of focus.

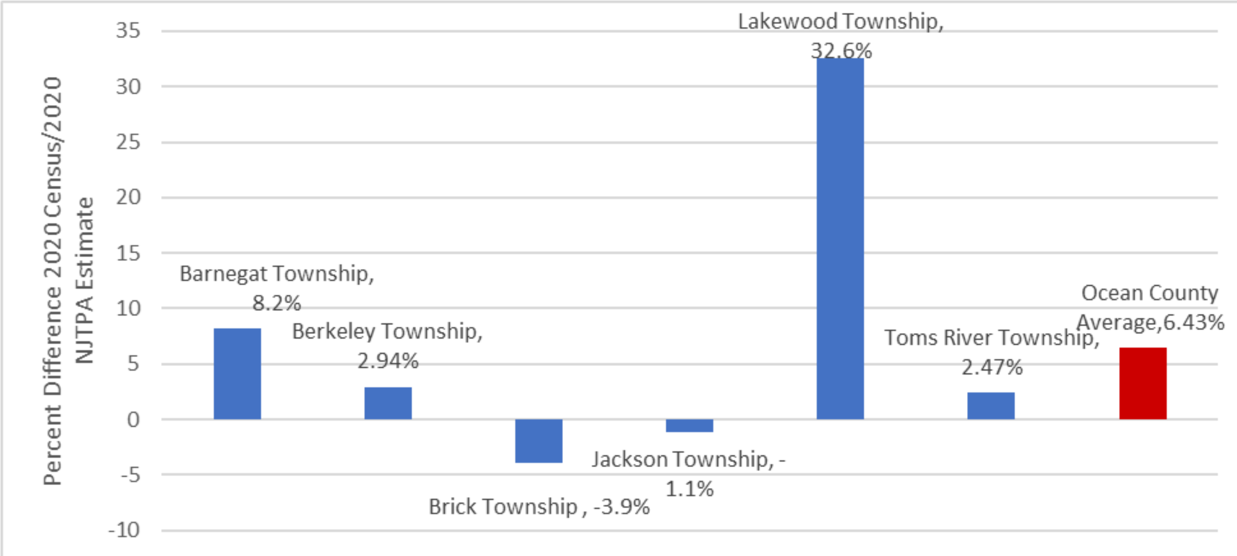

Figure I3. Percent Difference between 2020 Census Population & NJTPA Population Estimates for 2020 (Source: NJTPA & U.S Census Bureau, 2020)

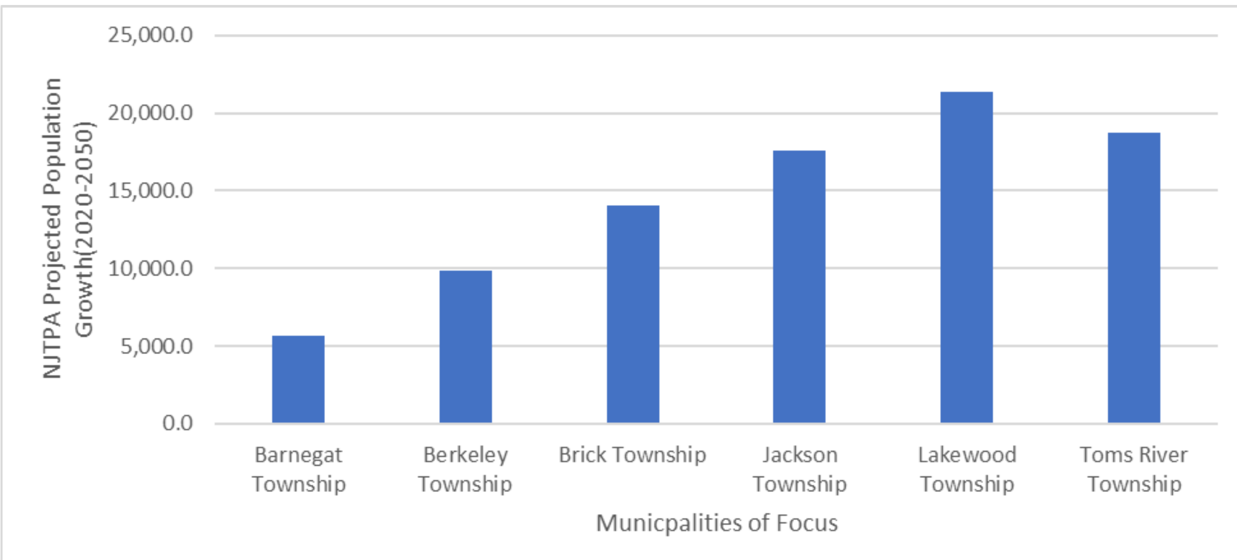

Figure I4. NJTPA Population Growth Forecasts between 2020-2050 for Municipalities of Focus in WMA 13 (Source: NJTPA, 2020)

5. SOCIAL VULNERABILITY

KEY FINDINGS

- There are 70 census block groups in WMA 13 identified as overburdened, and 46 of those are within the six municipalities of focus.
- The CDC Social Vulnerability Index for counties in WMA 13 is relatively low compared to the entire state. However, there are census tracts in WMA 13 with some of the highest overall SVI index scores in the state (Primarily in Lakewood Township).

5.1 NJDEP OVERBURDENED COMMUNITIES

In 2020, New Jersey's Environmental Justice Law was signed, which introduced the overburdened community definition for the state. Figure I5 shows communities defined as Overburdened in WMA 13. "Overburdened community" means any census block group, as determined in accordance with the most recent United States Census, in which: (a) at least 35 percent of the households qualify as low-income households; (b) at least 40 percent of the residents identify as a minority or as members of a State recognized tribal community; or (c) at least 40 percent of the households have limited English proficiency (NJDEP, 2022). Table I5 lists every municipality in WMA 13 that meets the overburdened definition and lists how many census block groups are overburdened. Table I6 focuses on each municipality of focus that has overburdened census blocks and lists which part of the overburdened community definition they met.

County	Number of Census Block Groups Overburdened	Municipality Name
Ocean	3	Barnegat Township
Ocean	7	Berkeley Township
Ocean	3	Brick Township
Ocean	1	Jackson Township
Ocean	1	Lacey Township
Ocean	2	Lakehurst Borough
Ocean	26	Lakewood Township
Ocean	1	Little Egg Harbor Township
Ocean	1	Long Beach Township
Ocean	10	Manchester Township
Ocean	1	Ocean Gate Borough
Ocean	2	Seaside Heights Borough
Ocean	2	South Toms River Borough
Ocean	3	Stafford Township
Ocean	6	Toms River Township
Ocean	1	Tuckerton Borough
Monmouth	4	Freehold Township
Monmouth	1	Howell Township

Table I5. Municipalities in WMA 13 with Census Block Groups Defined as Overburdened (Source: NJDEP, 2022)

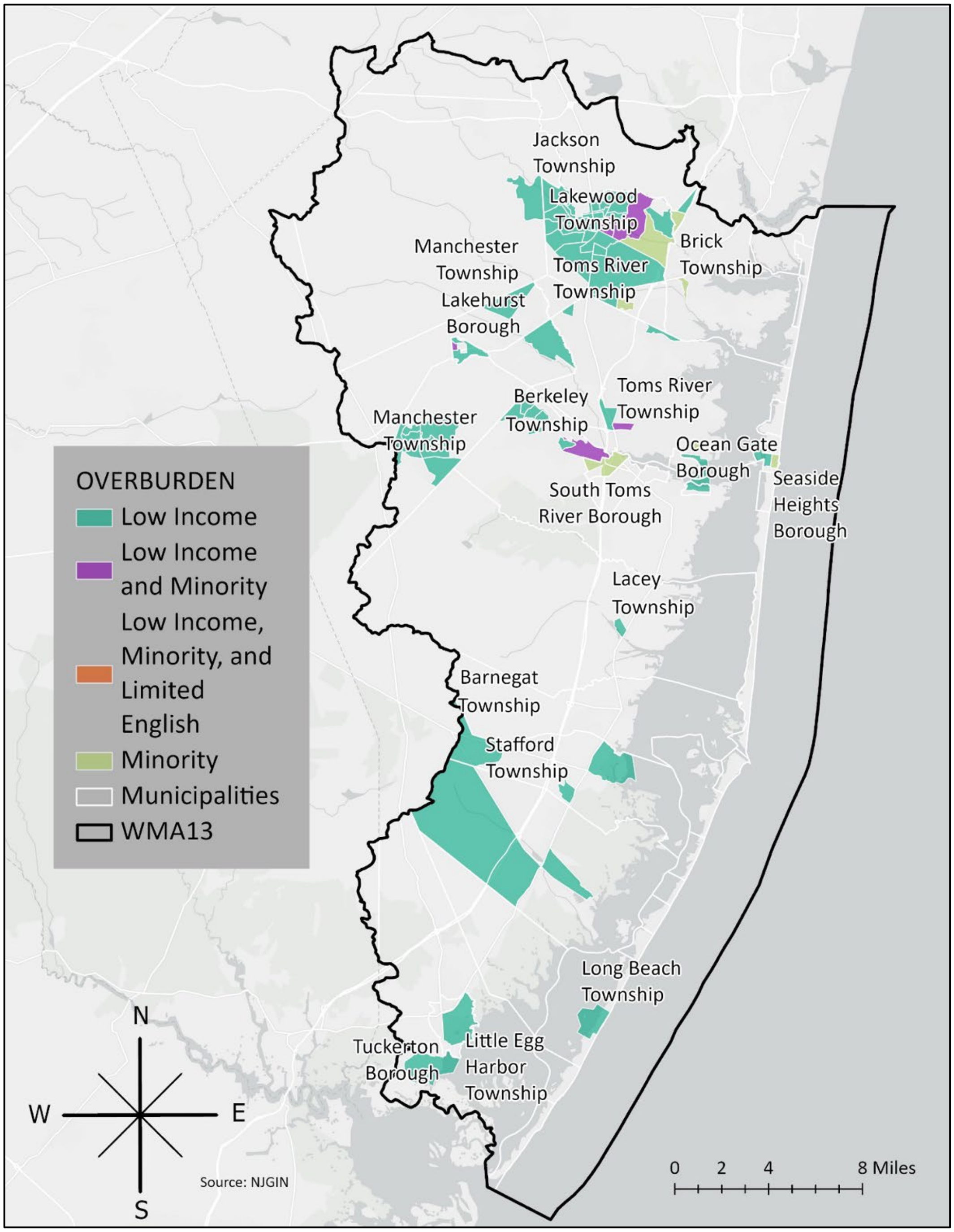

Figure I5. Communities Defined as Overburdened Communities in WMA 13 (Source: NJDEP, 2022)

Municipality	Number of Census Block Groups Overburdened	Overburdened Community Criteria in Census Block Groups
Barnegat Township	3	Low Income
Berkeley Township	7	Low Income (6), Minority (1)
Brick Township	4	Low Income (1), Minority (3)

Municipality	Number of Census Block Groups Overburdened	Overburdened Community Criteria in Census Block Groups
Jackson Township	2	Low-Income (2)
Lakewood Township	38	Low-Income (32), Low-Income & Minority (3) Minority (2), Minority & Limited English (1)
Toms River Township	9	Low-Income (4), Low-Income & Minority (4), Minority (1)

Table I6. Municipalities of Focus with Census Block Groups Defined as Overburdened (Source: NJDEP, 2022)

5.2 SOCIAL VULNERABILITY INDEX

While the overburdened community definition is helpful, there are more ways to capture the social vulnerability of a community. The CDC's Agency for Toxic Substances and Disease Registry created the Social Vulnerability Index (SVI) to define social vulnerability for census tracts in the U.S. The tool ranks census tracts by examining 16 social factors that relate to social vulnerability. Then, the CDC SVI aggregates these 16 factors by grouping them into the following themes: socioeconomic status, household characteristics, racial and ethnic minority status, and housing type/ transportation. Each census tract receives a ranking for each theme, as well as an overall ranking (Agency for Toxic Substances and Disease Registry, 2022). This database contains every census tract in New Jersey, so the social vulnerability of census tracts in WMA 13 is relative to every census tract in New Jersey. As vulnerability increases, the score increases (0-1).

County	Socioeconomic Status Percentile Ranking	Household Composition and Disability Percentile Ranking	Minority Status and Language Percentile Ranking	Housing Type and Transportation Percentile Ranking	Total SVI Index Percentile Ranking
Burlington	0.39	0.44	0.40	0.35	0.37
Monmouth	0.38	0.37	0.30	0.42	0.36
Ocean	0.48	0.41	0.17	0.37	0.39

Table I7. Social Vulnerability Index Percentile Values for Counties in WMA 13 (Source: CDC Agency for Toxic Substances and Disease Registry, 2022)

Census Track	Municipality	County	Socioeconomic Status Percentile Ranking	Household Composition and Disability Percentile Ranking	Minority Status and Language Percentile Ranking	Housing Type and Transportation Percentile Ranking	Total SVI Index Percentile Ranking
34029715202	Lakewood	Ocean	0.95	0.51	0.54	0.98	0.91
34029715001	Lakewood	Ocean	0.94	0.66	0.54	0.86	0.87
34029728004	Seaside Heights	Ocean	0.65	0.82	0.51	0.98	0.84
34029715304	Lakewood	Ocean	0.75	0.40	0.24	0.99	0.79
34029715301	Lakewood	Ocean	0.52	0.87	0.35	0.97	0.77

Table I8. Census Tracts in Ocean County with High Overall SVI Scores (Source: CDC Agency for Toxic Substances and Disease Registry, 2022)

Relative to New Jersey, counties in WMA 13 are less socially vulnerable. Ocean County has the highest overall SVI ranking in WMA 13, but it's not significantly different between the three counties. While it looks like communities in WMA 13 aren't socially vulnerable, it's important to note that there are some census block tracts in Ocean County that have high SVI indexes. Several examples come from Lakewood Township, a municipality of focus. Table I8 demonstrates how despite having a low county SVI Index, several census tracts in Ocean County have some of the highest census tracts overall SVI scores.

5.3 COMPARISON OF OVERBURDENED COMMUNITY AND SVI FINDINGS

When WMA 13's social vulnerability is compared to other areas of the state, using the CDC SVI tool, socially vulnerable census tracts get lost in the statewide data. Despite Ocean County having a low SVI score relative to the state, some census tracts in WMA 13 have the highest overall SVI scores in the state. Using the SVI tool in conjunction with the NJDEP OBC definition helps identify communities that might have gotten lost by one definition of socially vulnerable.

6. CURRENT LAND USE

KEY FINDINGS

- Several municipalities have urban land uses that account for more than 50% of their total land cover. Several municipalities of focus are built out, with minimal barren land.
- Development strategies aim to preserve the available open space and reduce the amount of development near category one waterways and other environmentally sensitive areas.

Area	Urban	Forest	Wetlands	Barren Land	Water	Agriculture
WMA 13 (2015)	22%	27%	17%	2%	32%	1%
Focus Municipalities						
Barnegat Township	23 %	22%	25%	2%	27%	0%
Berkeley Township	25%	32%	19%	3%	22%	0%
Brick Township	52%	8%	16%	1%	24%	0%
Jackson Township	27%	40%	27%	2%	2%	2%
Lakewood Township	62%	22%	11%	2%	2%	1%
Toms River Township	52%	13%	10%	1%	23%	0%

Table I9. Land Use/Land Cover for WMA 13 and Municipalities of Focus (Source: 2015 Land Use/Land Cover GIS Analysis from Data Obtained from NJGIN)

Table I9 presents land use data from the 2015 Land Use assessment for WMA 13. Overall, natural resources define the watershed, with 32% land cover designated as water, 27% forested, and 17% of WMA 13 is covered by wetlands. Second to the natural resources, is the development of urban land, which is almost 22% of the WMA. There isn't much barren land (2%), and almost no agriculture use (1%). Similar trends follow the municipalities of focus. The table shows how land use total percentages vary by municipality. There are several municipalities (Brick Township, Lakewood Township, and Toms River Township) with urban land use greater than 50%. These municipalities are near two C1 waterways (Toms River and the Metedeconk River).

Lakewood Township is the fifth largest municipality in the state. The municipality is growing. To address future land use concerns, the municipality is exploring the following:

- clustering and reasonable density household developments, and
- finding new areas to designate as park and recreation space.

(Source: Lakewood Master Plan, 2017)

6.1 OPEN SPACE, PARKS & RECREATION

Managing Ocean County's publicly owned land is an ongoing priority of WMA 13. The natural landscape of WMA 13 provides amenities from its water resources and habitats and ecosystem goods and services (Kauffman & Curz-Ortíz, 2012). Ocean County's Open Space, Parks, and Recreation Plan identifies that the county is growing, which means more lands need to be preserved to protect water quality and provide recreation spaces for its growing population. Since 1997, Ocean County has had a natural land tax, which was recently expanded in 2019. The tax is used to support Ocean County's Natural Land Trust land acquisitions for recreation and conservation purposes (Ocean County, Open Space Plan, 2020). Table I10 lists the total number acres owned by state, county, and federal agencies.

Landowner	Total Number of Acres
Federal	47,669
State	107,648
Ocean County	155,318
Total	310,635

Table I10. Open Space, Parks, and Recreation Owned by Federal, State, and Local Agencies (Source: Ocean County's Open Space, Parks, and Recreation Plan, 2020)

According to the Open Space Plan, future acquisitions will prioritize the following areas in Ocean County (Ocean County, 2020):

1. stream corridors and other flood prone areas;
2. aquifer recharge areas;
3. buffer areas surrounding potable well fields;
4. environmentally sensitive areas;
5. active farms and lands with prime agricultural soils;
6. lands adjacent to environmentally sensitive areas; and
7. lands in close proximity to Joint Base McGuire-Dix-Lakehurst.

(Source: Ocean County Open Space, Parks, and Recreation Plan, 2020)

7. WATER AVAILABILITY AND DEMAND ANALYSIS

KEY FINDINGS

- The weighted average of water use in WMA 13 from 2016-2020 was 26,867 million gallons per year.
- Water withdrawals for potable supply uses drives water demand in WMA13. In 2020, potable drinking supply water withdrawals accounted for 77.3% of total withdrawals in WMA 13.
- The majority of withdrawals in WMA13 are from HUC11 02040301080 (Toms River, below Oak Ridge Parkway), 02040301040 (Metedeconk River), and HUC11 02040301130 (Lower Little Egg Harbor Tributary).
- Based on estimates from the Low Flow Margin the following HUC11s are stressed: HUC 11 02040301050 (Kettle Creek / Barnegat Bay North), HUC11 02040301060 (Toms River, above Oak Ridge Parkway), HUC11 02040301080 (Toms River, below Oak Ridge Parkway), and HUC11 02040301040 (Metedeconk River).
- The Northern portion of WMA13 (near the Metedeconk River) continues to experience high levels of nutrient loading, which is leading to eutrophication of the bay. The Southern portion of WMA13 is experiencing turbidity issues (Comprehensive Conservation and Management Plan for the Barnegat Bay-Little Egg Harbor Estuary, 2021).
- Since 2012, there have been 32 impaired water designations as defined by the New Jersey's 303(d), to waterbodies designated as public water supply in WMA 13. Stormwater was the primary source of these impairments (Metedeconk River Watershed Protection Plan, 2021).

Figure I6 shows water withdrawals from 1990-2020. In 2020, water withdrawals in WMA 13 came from the following sources: surface water (23%), unconfined groundwater (34%), confined groundwater (43%). Between 2018-2020, the total percentage of withdrawals by source is similar. Since 2018, more water has been withdrawn from surface waters sources.

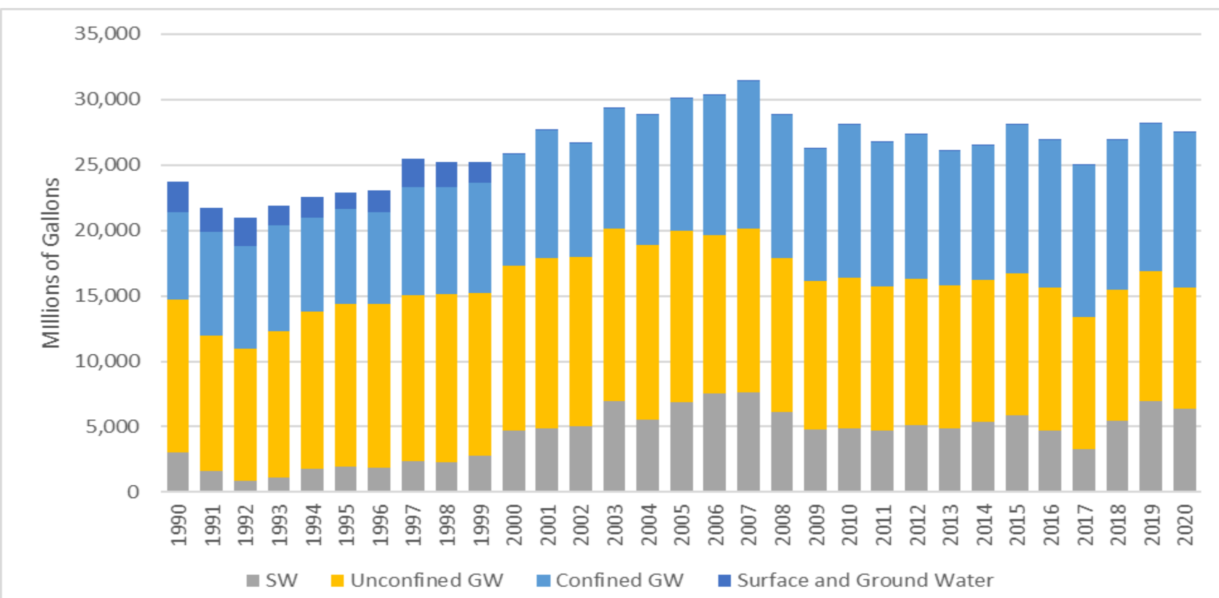

Figure I6. WMA 13 Annual Withdrawals by Source (Source: NJDEP DGS-10-3, 2022)

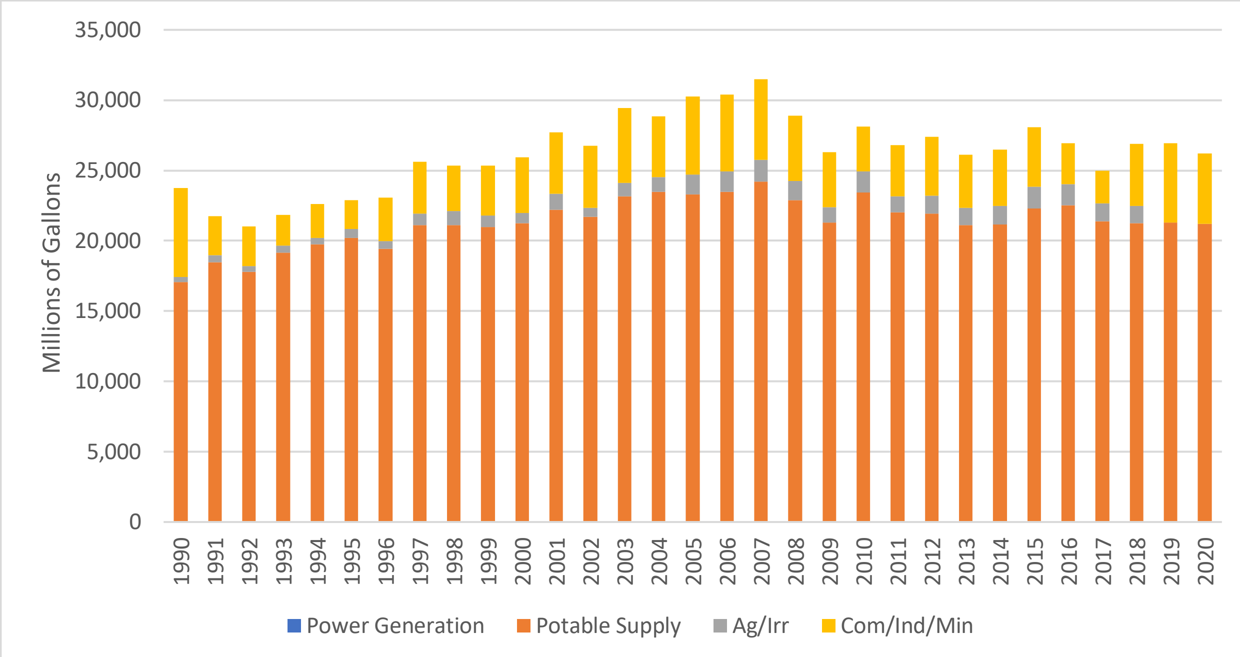

Figure I7. Annual Withdrawals by Use Sector (Source: NJDEP DGS 10-3, 2022)

Figure I7 shows how withdrawals are used in WM13. As shown in Figure I7, annual withdrawals grew steadily between 1990-2007, peaking in 2007. After 2008, total water withdrawals decreased slightly. Over time, the percentage of water going to each water use has remained similar. Potable supply drives most water withdrawals in WMA 13. In 2017, the total percentage of water withdrawals going to potable supply uses peaked at 85.7%. Since 2017, that number decreased slightly. In 2020, potable drinking supply water withdrawals accounted for 77.3% of total withdrawals in WMA 13. The percentage of water withdrawals for commercial industries was the following in 2020: commercial (0.0%), industrial (12.2%), and mining (5.9%). In 2020, 3.8% of total water withdrawals went to irrigation uses. Less than 1% of WMA13'S total water withdrawals in WMA13 went to agriculture (0.8%).

Figure I8 shows annual discharges in WMA 13 by source. Following trends of previous years, almost all discharges are to surface water saline sources (see Figure I8), through regional wastewater treatment facilities. In recent years, a small percentage of annual discharges are to surface water fresh sources.

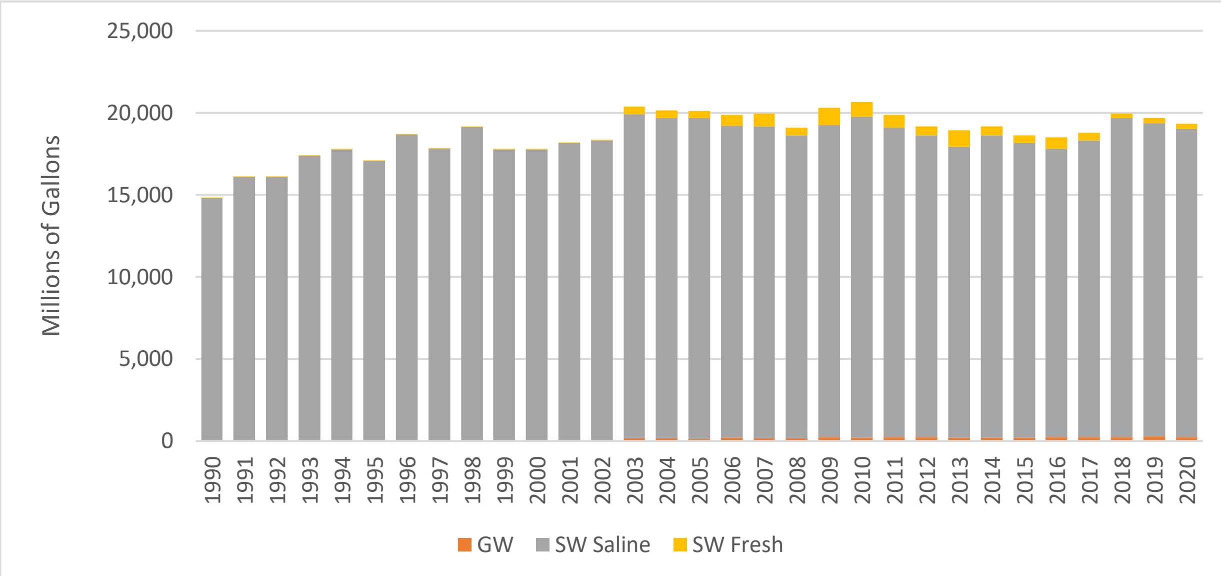

Figure I8. WMA 13 Annual Discharges by Source (Source: NJDEP DGS 10-3, 2022)

7.1 WATER QUANTITY

Figure I9 shows the 5-year (2016-2020) average water withdrawals in WMA 13 by HUC11. From 2016-2020, HUC11 02040301080 (Toms River, below Oak Ridge Parkway) had the largest average water withdrawal, averaging 5,022 million gallons. The second largest average water withdrawal was HUC11 02040301040 (Metedeconk River), with an average of 3,936 million gallons. HUC 11 02040301130 (Manahawkin/Upper Little Egg Harbor tribs) averaged 3,226 million gallons.

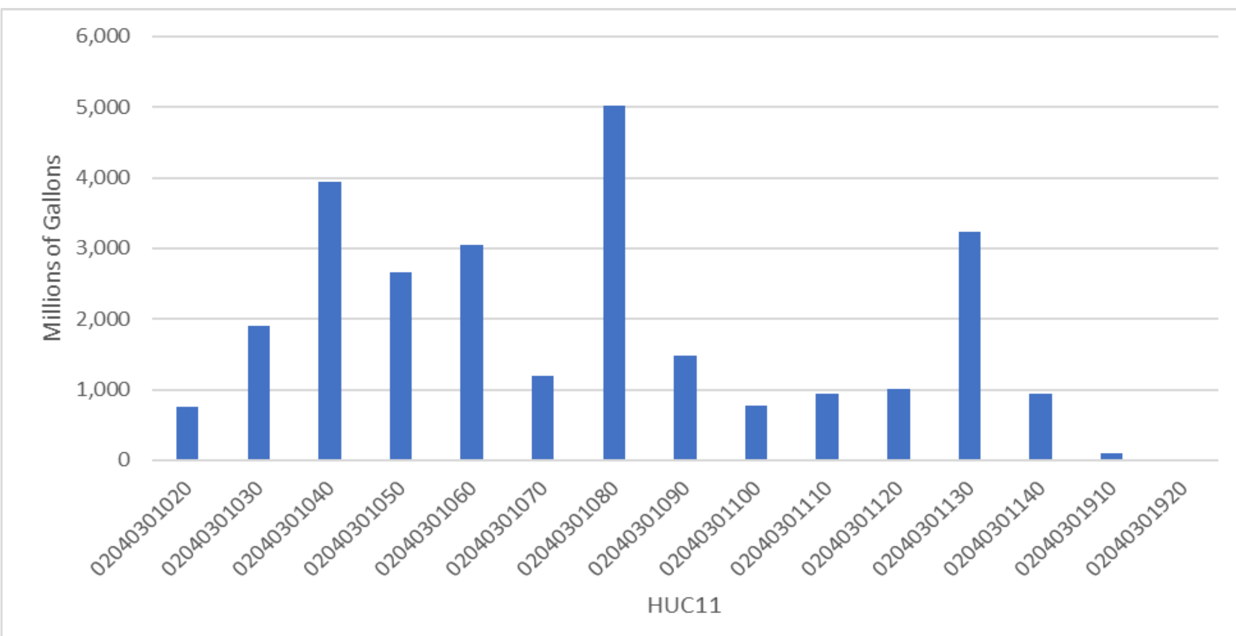

Figure I9. 5-Year (2016-2020) Average Water Withdrawals by HUC11 in WMA 13 (Source: NJDEP DGS 10-3, 2022)

NJDEP's streamflow Low Flow Margin method is a metric NJDEP uses to assess which HUC11'S are potentially limited in a watershed. The method examines the 3-year average peak in consumptive/depletive water loss, for unconfined aquifers and surface waters sources. This assessment looks at the consumptive/depletive water from 2010-2020. Table I11 presents the status of each HUC11 in WMA 13, which is based on the percentage of total available water used in each HUC11. There are two designations for HUC11s in WMA13: not stressed (11) and potentially limited (4). HUC11s are potentially stressed when the HUC11's depletive/consumptive loss is greater than their total water availability.

Status	Number of HUCs	HUC 11 Name
Not Stressed	11	Metedeconk River NB (02040301020) Metedeconk River SB (02040301030) Union/Ridgeway Branch (Toms River) (02040301070) Cedar Creek (02040301090) Barnegat Bay Central & Tribs (02040301100) Forked River / Oyster Creek (02040301110) Waretown Ck / Barnegat Bay South (02040301120) Manahawkin/Upper Little Egg Harbor tribs (02040301130) Lower Little Egg Harbor Bay tribs (02040301140) Atlantic Coast (Manasquan to Barnegat) (02040301910) Atlantic Coast (Barnegat to Little Egg) (02040301920)
Potentially Stressed	4	Metedeconk River (02040301040) Kettle Creek / Barnegat Bay North (02040301050) Toms River (above Oak Ridge Parkway) (02040301060) Toms River (below Oak Ridge Parkway) (02040301080)

Table I11. WMA 13 Percent of Total Water Available Used (Average 3-Year Peak Depletive and Consumptive Loss, 2011-2020) (Source: NJDEP LFM V3, 2023)

Figure I10 shows the remaining available water from the highest 3-year peak demand experienced by each HUC11 (from 2010-2020). While HUC11 02040301040 (Metedeconk River) is the most stressed in terms of the current percent of available water used, HUC11 02040301080 (Toms River, below Oak Ridge Parkway) had the largest deficit where its 3-year average peak withdrawal (2012-2014) greatly exceeded, total available water as calculated by the LFM methodology, the net amount was less than 0 mgy. The Metedeconk River's remaining available water from its 3-year average peak loss (2011-2013) also exceeded total water availability (LFM methodology), which resulted in its net amount being less than 0 mgy (Source: NJDEP LFM, 2023). As always, the withdrawal data have a higher degree of certainty than the LFM methodology; these values are used as indicators of stress and are not used as definitive results by NJDEP.

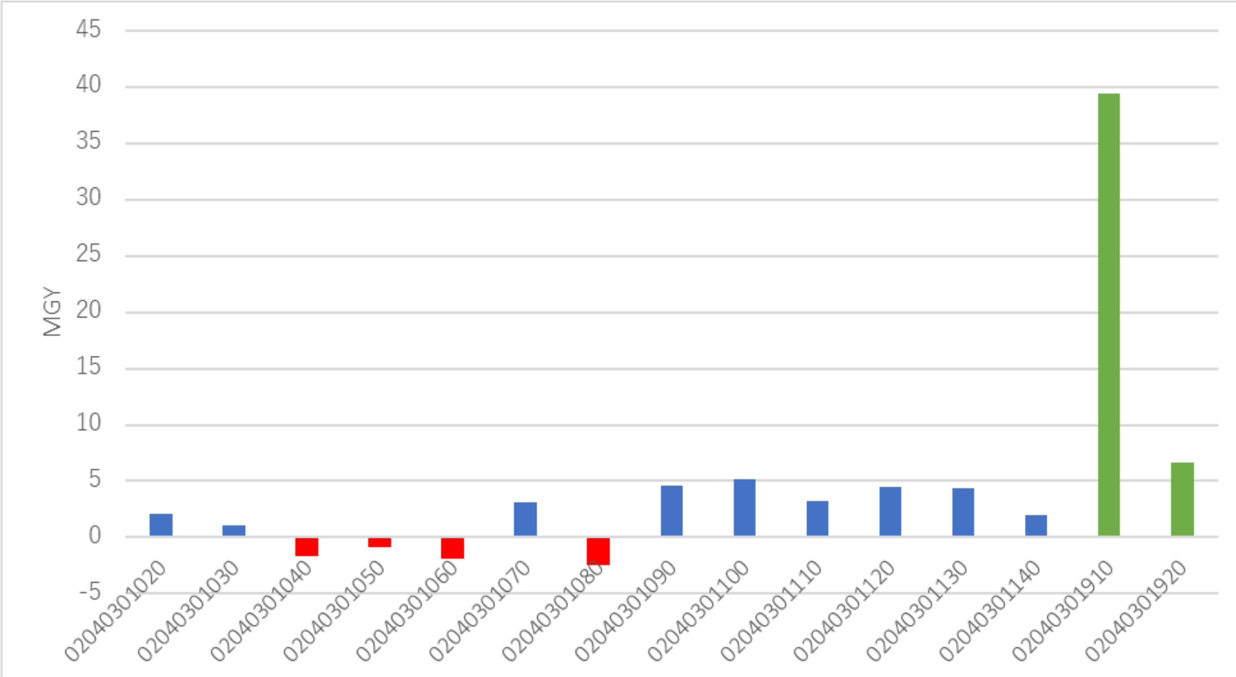

Figure I10. WMA 13 HUC11's Remaining Available Water for the Average 3-Year Peak Loss (Source: NJDEP LFM V3, 2023)

7.2 WATER QUALITY

There are a variety stakeholders and organizations at the federal, state, county, and municipal level working to restore and improve water quality in WMA 13. In 2016, NJDEP released the New Jersey Integrated Water Quality Assessment Report. In 2021, NJDEP created the Metedeconk River Watershed Protection Plan for WMA 13. In 2017, Brick Township Municipal Utilities Authority (BTMUA) created the Metedeconk River Watershed Protection Plan, and in 2021, the Barnegat Bay Partnership addressed water quality issues in the Bay in its Comprehensive Conservation Management Plan.

Sources of Pollutants in WMA13:

- **Point Source:** In WMA13, point sources are not a major concern; there's only one active point source discharge regulated by NJDEP (Metedeconk River Watershed Protection Plan, 2021).
- **Nonpoint Source:** A lot of pollutant loading in the watershed comes from non-point sources. Examples of non-point sources include stormwater discharges not subject to regulation and stormwater runoff (Metedeconk River Watershed Protection Plan, 2021).
- **Land Use:** As land use changes in the watershed to more urban uses, the amount of impervious surfaces increase, which increases stormwater runoff (nonpoint source) in the watershed.

Threats to the Metedeconk River's Water Quality include the following:

- **Nutrient Loading:** The amount of nitrogen and phosphorus in the Metedeconk River Watershed is causing eutrophication in parts of the Metedeconk River, lakes in the watershed, and harming the Metedeconk River Estuary and Barnegat Bay (Metedeconk River Watershed Protection Plan,

2017). Residential development and its impervious surface composition in the northern part of WMA 13 is contributing to the higher Nitrogen loading counts in bay.

- **Algal Blooms:** The Northern part of the Bay is experiencing algal blooms with increasing frequency and intensity, which is related to the nutrient loading issues previously mentioned (Comprehensive Conservation and Management Plan for the Barnegat Bay-Little Egg Harbor Estuary, 2021).

Pollutant Causing a Designated Use Impairment	Impaired Waterbodies Count
Arsenic ***TMDL Priority Ranking: Low***	23
Benzene ***TMDL Priority Ranking: Low***	1
Lead ***TMDL Priority Ranking: Low***	3
Mercury in Water Column ***TMDL Priority Ranking: Low***	2
Tetrachloroethylene ***TMDL Priority Ranking: Low***	1
Total Dissolved Solids (TDS) ***TMDL Priority Ranking: Medium***	1
Vinyl Chloride ***TMDL Priority Ranking: Low***	1
Total Count of Impaired Waterbodies in WMA 13	**32**

Table I12. 2020 3030(d) List of Impaired Waterbodies, Designated for Public Water Supply (EPA, 2020)

NJDEP has been monitoring nonpoint source pollutants relates to public water supply (EPA NJ Impaired Waters List, 2020). Table I12 shows how many times a pollutant has impaired a waterbody in WMA13 from 2012-2020. Stormwater runoff was the primary cause of most of these pollutants (Metedeconk River Watershed Protection Plan, 2021). To mitigate these impairments, NJDEP established Total Maximum Daily Loads (TMDL) plans for five high priority pollutants identified in Integrated Water Quality Assessment Reports. Pollutants regulated by TMDLs are the following: fecal coliform, total coliform, nitrogen, mercury, and total phosphorous (Metedeconk River Watershed Protection Plan, 2021).

Strategies to Improve and Restore WMA13's Water Quality:

- Category One Waters
  - New Jersey Pollutant Discharge Elimination System (NJDPES) Rules at N.J.A.C.7:14A
  - Flood Hazard Ara Control Act Rules at N.J.A.C. 7:13
- Public Law 2010
- New Jersey State Fertilizer Law P.L. 2010, c.112 (C.58:10A-64 et seq.)
- Soil Restoration Act (P.l.2010, c. 113)

(Source: Metedeconk River Watershed Protection Plan, 2021)

8. WATER UTILITIES AND WATER INFRASTRUCTURE

KEY FINDINGS

- In WMA 13, Berkeley Township MUA (16.13%), Brick Township MUA (34%), and Lakewood Township MUA (21.56%) had some of the highest large water demand increases between 2011-2020.
- Water demands projections for PCWS in 2050 show that system's surpluses will decline. Barnegat Township MUA, Jackson Township MUA, and Ocean Township Department of Utilities are projected to experience surplus deficits by 2050.

There are 39 public community water systems that serve over 1,000 residents in WMA 13 (NJDEP Data Miner, 2022). Table I13 lists the PCWS that serve the municipalities of focus in this report.

County	Municipality of Focus Served	PWID	System Name	Max Population Served	Water Sources	Number of Wells
Ocean	Jackson Twp	1511001	Jackson Twp MUA	35,424	Englishtown Aquifer, Vincentown Aquifer, Upper Potomac-Raritan-Magothy Aquifer System	9
Monmouth	Brick Twp, Lakewood Twp, Toms River Twp	1345001	NJ American - Coastal North	69,730	Englishtown Aquifer, Kirkwood-Cohansey, Mount Laurel-Wenonah, Potomac-Raritan-Magothy, Upper Potomac-Raritan-Magothy, Vincentown	19
Ocean	Brick Twp	1506001	Brick Twp MUA	86,898	Metedeconk River, Potomac-Raritan-Magothy Aquifer, Kirkwood-Cohansey Aquifer	11
Ocean	Berkeley Twp, Toms River Twp	1507005	Veolia Water-Toms River	123,187	Kirkwood-Cohansey, Piney Point, Potomac-Raritan-Magothy, Upper Potomac-Raritan-Magothy	24
Ocean	Barnegat Twp	1520001	Ocean Twp Department of Utilities	2,836	Rio Grande Water-Bearing Zone, Atlantic City "800-foot" Sand Aquifer System	5
Ocean	Barnegat Twp	1533001	Barnegat Twp Water & Sewer Utilities	20,000	Kirkwood-Cohansey Aquifer	6
Ocean	Barnegat Twp	1533002	Pinewood Estates-Brighten	1,493	Kirkwood-Cohansey Aquifer	3

County	Municipality of Focus Served	PWID	System Name	Max Population Served	Water Sources	Number of Wells
Ocean	Berkeley Twp	1505002	Aqua NJ – Eastern Division	12,000	Kirkwood-Cohansey Aquifer System	3
Ocean	Berkeley Township	1505003	Shore Water Company	6,600	Kirkwood-Cohansey Aquifer System	3
Ocean	Berkeley Twp	1505004	Berkeley Twp MUA	11,235	Piney Point Aquifer	3
Ocean	Lakewood Twp	1514002	Lakewood Twp MUA	21,750	Potomac-Raritan-Magothy Aquifer System, Englishtown Aquifer, Kirkwood-Cohansey Aquifer System	9

Table I13. PCWS (>1,000) that Serve the Six Municipalities of Focus (Source: NJ Community Water System Source Water Assessment Summaries, 2022)

Table I14 analyzes the current demand patterns of the large purveyors (>1,000 people served) that serve the municipalities of focus. In 2020, New Jersey American Water Company (NJAWC)-Coastal had the largest water demand of 8,960 mgy. Brick Township MUA's water demand increased the most, with a 34% percent change between 2011 to 2020. Table I15 explores different water demand forecasts for 2050, considering various conservation options for PCWS. Most PCWS surpluses are projected to decrease by 2050. Under 2050 Conservation scenarios, Berkeley Township MUA and NJAWC-Coastal North surpluses are projected to increase. Barnegat Township MUA, Jackson Township MUA, and Ocean Township Department of Utilities are projected to experience negative water loss scenarios by 2050.

System Name	2020 Demand (mgy)	Demand Percent Change (2011-2020) (%)	Average Demand (mgy)	Max Demand (mgy)	Average Demand (mgd)
Aqua NJ – Eastern Division (Berkeley Water Co)	282	-8	288	305	1
Barnegat Twp Water & Sewer Utilities	723	0	678	725	2
Berkeley Twp MUA	284	16	256	284	1
Brick Twp MUA	2,269	34	1,912	2,348	5
Jackson Twp	1,131	-9	1,183	1,281	3
Lakewood Twp MUA	1,272	22	1,214	1,561	3
NJAWC -Coastal North	8,960	-3	12,724	14,883	35
Ocean Twp Department of Utilities	382	16	360	392	1
Pinewood Estates-Brighten	31	-8	32	36	0
Shore Water Company	59	5	58	66	0

System Name	2020 Demand (mgy)	Demand Percent Change (2011-2020) (%)	Average Demand (mgy)	Max Demand (mgy)	Average Demand (mgd)
Veolia-Toms River	3,907	-15	4,421	4,618	12

Table I14. Public Community Water Systems (That Serve >1,000 People) in WMA 13 and Their Water Demands (Source: NJDEP, 2022)

Purveyor and 2020 Status				2050 No Conservation Scenario		2050 Conservation Scenario	
PSWID	Purveyor Name	Average Daily Demand (2020) (mgd)	2020 Deficit Surplus (mgd)	Nominal Water Loss Scenario (mgd)	Optimal Water Loss Scenario (mgd)	Nominal Water Loss Scenario (mgd)	Optimal Water Loss Scenario (mgd)
NJ1505002	Aqua NJ – Eastern Division	0.8	0.4	0.0	0.1	0.1	0.2
NJ1533001	Barnegat Twp Water & Sewer Utilities	1.9	0.7	-0.6	-0.4	-0.4	0.1
NJ1505004	Berkeley Twp MUA	0.7	0.8	1.9	1.9	1.9	1.6
NJ1506001	Brick Twp MUA	8.7	7.4	5.1	5.9	5.7	6.8
NJ1511001	Jackson Twp MUA	3.1	2.4	-0.7	-0.3	-0.3	0.9
NJ1514002	Lakewood Twp MUA	4.2	0.4	0.7	1.2	0.9	1.0
NJ1345001	NJAWC-Coastal North	47.5	9.3	4.7	8.7	10.7	12.7
NJ1520001	Ocean Twp Dept. of Utilities	1.1	0.4	-0.2	-0.1	-0.2	0.1
NJ1533002	Pinewood Estates-Brighten	0.1	0.0	0.0	0.0	0.0	0.03
NJ1505003	Shore Water Company	0.2	0.1	0.1	0.1	0.1	0.1
NJ1507005	Veolia Water-Toms River	10.8	7.1	4.0	5.0	4.9	6.3

Table I15. 2050 Demand Projections for PCWS Serving Municipalities of Focus (Source: NJDEP, 2023)

8.1 RELATIONSHIP BETWEEN WATER USE AND PROJECTED DEMOGRAPHIC CHANGES

Most PCWS discussed above serve major population centers in WMA 13. Veolia Toms River serves Toms Rivers Township and sections of Berkeley Township (NJ DEP Data Miner, 2022). Berkeley Township and Toms River are municipalities of focus in WMA 13 because their population growth exceeded MPO estimates in 2020. New Jersey American Water Coastal North serves 35 municipalities, mostly north of WMA 13 but including Brick Township, Lakewood Township, and Toms River Township (NJ DEP Data Miner, 2022). These townships are municipalities of focus.

The population these purveyors serve is going to increase. As shown through the 2050 demand projections, water demand is going to increase for communities in WMA 13.

9. CLIMATE CHANGE AND SEA LEVEL RISE ASSESSMENT

KEY FINDINGS

- The major drivers of climate change as they relate to WMA 13's water supplies are precipitation, temperature, and sea level rise.
- In WMA 13, when sea level rises 2ft, 63 wells associated with water allocation sites are at risk of inundation. When sea level rises to 5ft, 305 wells are at risk.
- In WMA 13, when sea level rises 2ft and 5ft, 9.8% to 20.5% of the total PCWS service areas becomes inundated respectively.
- In WMA 13, when sea level rises 2ft, 15 overburdened census block groups are completely inundated. When sea level rises to 5ft, the number of overburdened census block groups increases to 18.

9.1 CLIMATE CHANGE DRIVERS AND THEIR IMPACT ON WATER SUPPLIES

PRECIPITATION

New Jersey precipitation models predict that the average annual precipitation will increase slightly over time in the state, with minimal regional differences (2020 NJ Scientific Report on Climate Change, 2020). New Jersey's coastal areas average 44 inches of rain, which is less than northern and southern parts of the state (Office of New Jersey State Climatologist, 2020). In addition, coastal areas are expected to experience more precipitation extremes in the fall and spring relative to inland areas (2020 NJ Scientific Report on Climate Change, 2020).

100-yr Return Period RCP 4.5 Projection 2020-2069 - OCEAN

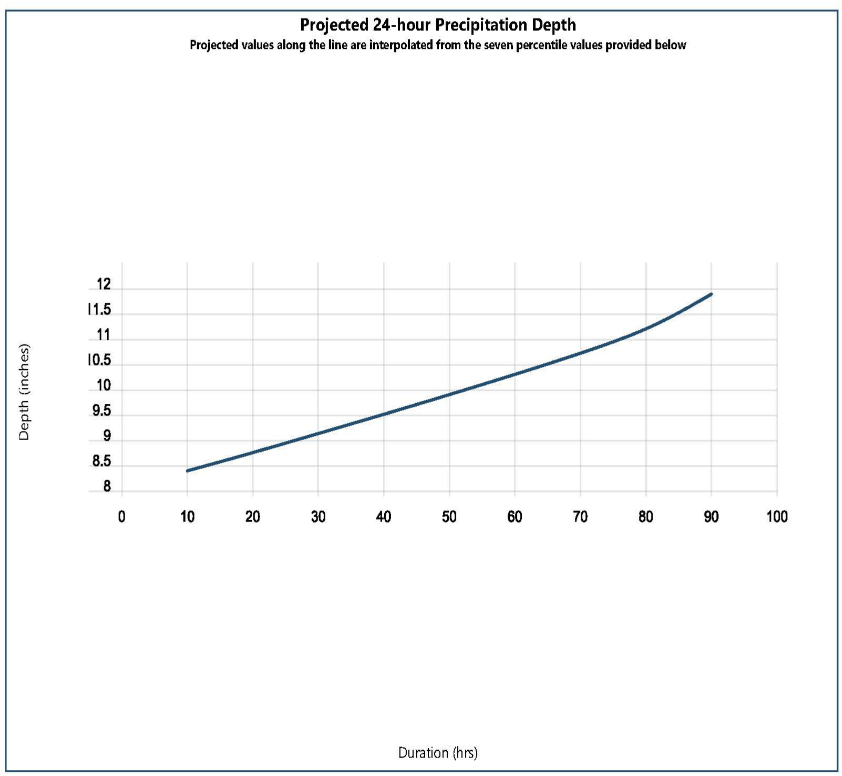

Figure I11. Precipitation Depth (Inches) Associated with a 24-hour Storm with a 1% Chance (100-year Storm) of Occurring in Any Given Year under a Moderate Emission Scenario (RCP 4.5). Prediction for 2020-2069 Future Emission Scenario. (Source: NJ Extreme Precipitation Projection Tool, 2023)

Despite the minimal change in the average annual precipitation, the frequency and severity of precipitation will change. Precipitation intensity will increase and

there will be longer durations of drier periods (Agel et al., 2015). These variations in water availability could put stress on water systems, which could lead to more water-supply declared droughts.

Precipitation projections for Ocean County supports findings that there's a high likelihood that precipitation intensity will increase. Figure I11 shows the regional estimate for projected changes in extreme rainfall amounts (inches) within a 24-hour period in Ocean County. Using this projection, for the 100-year return period, moderate RCP4.5 emission scenario, and the 2050 to 2099 period for Ocean County, there is a 75% chance that the 24-hour precipitation amount will be equal to or less than 10.92 inches. There is a 25% chance that a 100-year 24-hour precipitation event will be equal to or less than 8.95 inches.

TEMPERATURE

New Jersey's annual temperature is rising and is expected to continue to rise over the 2050 planning period. Heatwave events are expected to occur more frequently with longer durations. It's estimated that by 2050, annual temperatures in the state will increase by 4.1°F to 5.7°F.

Here are some ways higher temperatures can impact water supplies:

- increased water demand;
- reduced water availability; and
- increased water loss through evapotranspiration.

(Source: 2020 NJ Scientific Report on Climate Change, 2020)

SEA LEVEL RISE

The rate of sea level rise in the Northeast U.S. has been higher than global rate and is expected to continue (2020 NJ Scientific Report on Climate Change, 2020). One of the key findings from the 2020 New Jersey Scientific Report on Climate Change is that "By 2050, there is a 50% chance that sea level rise will meet or exceed 1.4 feet and a 17% chance that it will exceed 2.1 feet. Those levels increase to 3.3 and 5.1 feet by the end of the century (under a moderate emission scenario)" (p. xi). Figure I12 presents the sea level rise projections noted above, with their likelihood estimates (Kopp et. al, 2019).

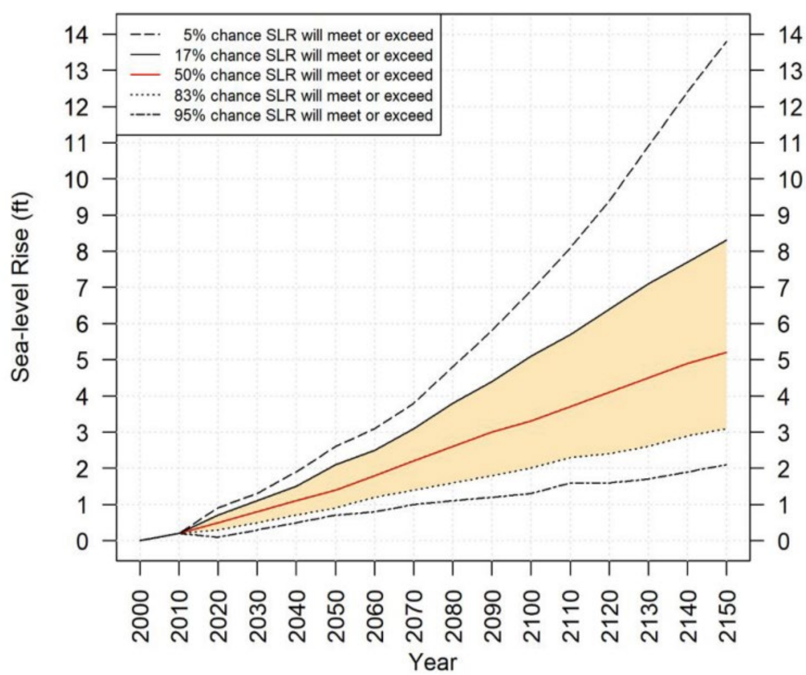

Figure I12. Moderate Emission Scenario
(Kopp et al., 2019)

Based on these findings, climate change scenarios in this report will focus on 2ft and 5ft sea level rise scenarios for WMA 13.

Sea level rise is an important phenomenon to study regarding potable water supplies because of its ability to induce saltwater intrusion to freshwater sources (WSP Presentation: WSP Climate Change Impacts, 2023). In New Jersey, unconfined aquifers systems are the most at risk of SLR induced saltwater intrusion. Potable supply wells near the ocean and estuaries are especially at risk (2020 NJ Scientific Report on Climate Change, 2020). Most of the communities along the coast are actively managing their water supplies and water demand to prevent saltwater intrusion.

9.2 POTENTIAL CHANGES TO WMA 13 WATER AVAILABILITY DUE TO CLIMATE CHANGE

There are various ways climate change can impact water supplies in the future. Impacts to water supplies include:

- water demand;
- water quality/treatment;
- saltwater intrusion wells/intakes;
- changes to aquifer availability; and
- inundation of public infrastructure.

(Source: WSP Presentation: WSP Climate Change Impacts, 2023)

Below are some of the ways to assess how climate change will affect WMA 13's water supplies.

WMA 13 SITE INUNDATION FROM SEA LEVEL RISE

One way to examine threats to WMA13's water supplies is to examine the active withdrawal and discharge sites (from 2016-2020) that would be inundated under 2ft and 5ft sea level rise.

Using data of wells associated water allocation in WMA 16 (from 2016-2020), a GIS analysis was performed to determine the number of wells that would be inundated by 2ft and 5ft of sea level rise. The data for these wells is from the New Jersey Water Database, which includes primary water allocation permitted sites and NJDEPS sanitary sewer discharge points. While this analysis is useful, all estimates should be considered approximate. The actual number of sites may vary.

HUC11	Number of Inundated Permits(2ft)	Number of Inundated Permits (5ft)
Withdrawal Permits		
02040301040	14	54
02040301050	5	43
02040301080	20	43
02040301090		10
02040301100		25
02040301110		5
02040301120		23
02040301130		48
02040301140	5	35
Discharge Permits		
02040301910	14	14
02040301920	5	5

Table I16. Number of Inundated Sites by 2ft and 5ft Sea Level Rise in WMA 13 by HUC11 (Source: NJDEP, NOAA)

The sea level rise data comes from NOAA's Sea level Rise Viewer and represents the mean higher water

conditions: the average of the higher of the daily high tides over the National Tidal Datum Epoch (1983-2001) (NOAA Sea Level Rise Viewer, 2022). When sea level rises 2ft, 63 withdrawal wells associated with water allocation permits will be inundated (see Table I16). When sea level rise rises 5ft, 305 wells will be inundated (see Table I16). Exploring withdrawal permit use groups shows that between 2ft and 5ft sea level rise, potable supply wells become more vulnerable (see Figure I13).

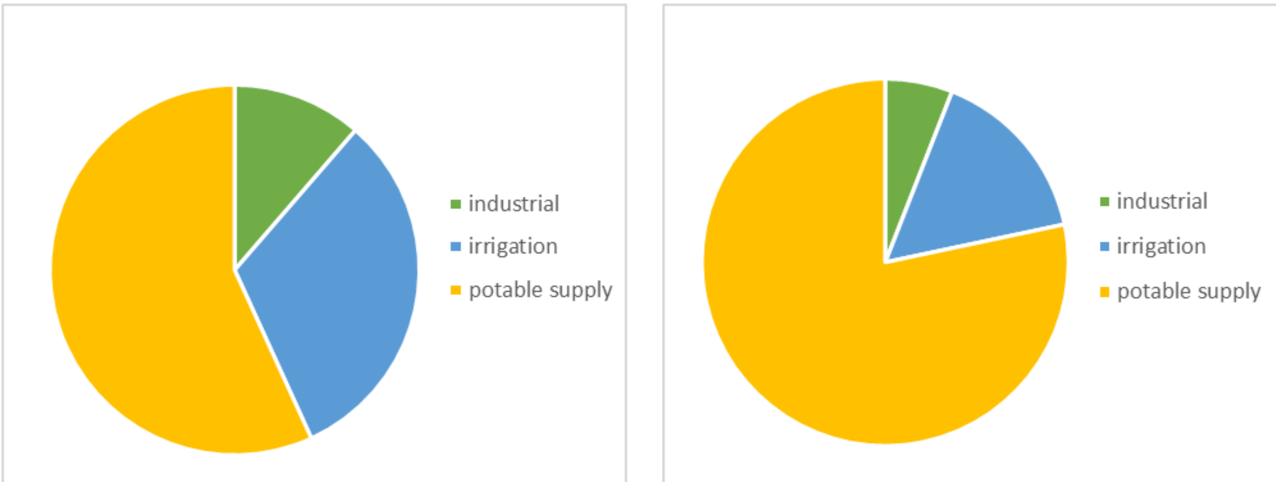

Figure I13. (Left) WMA 13 Withdrawal Permits Inundated by Use Group (2ft SLR); (Right) WMA 13 Withdrawal Permits by Use Group (5ft SLR)

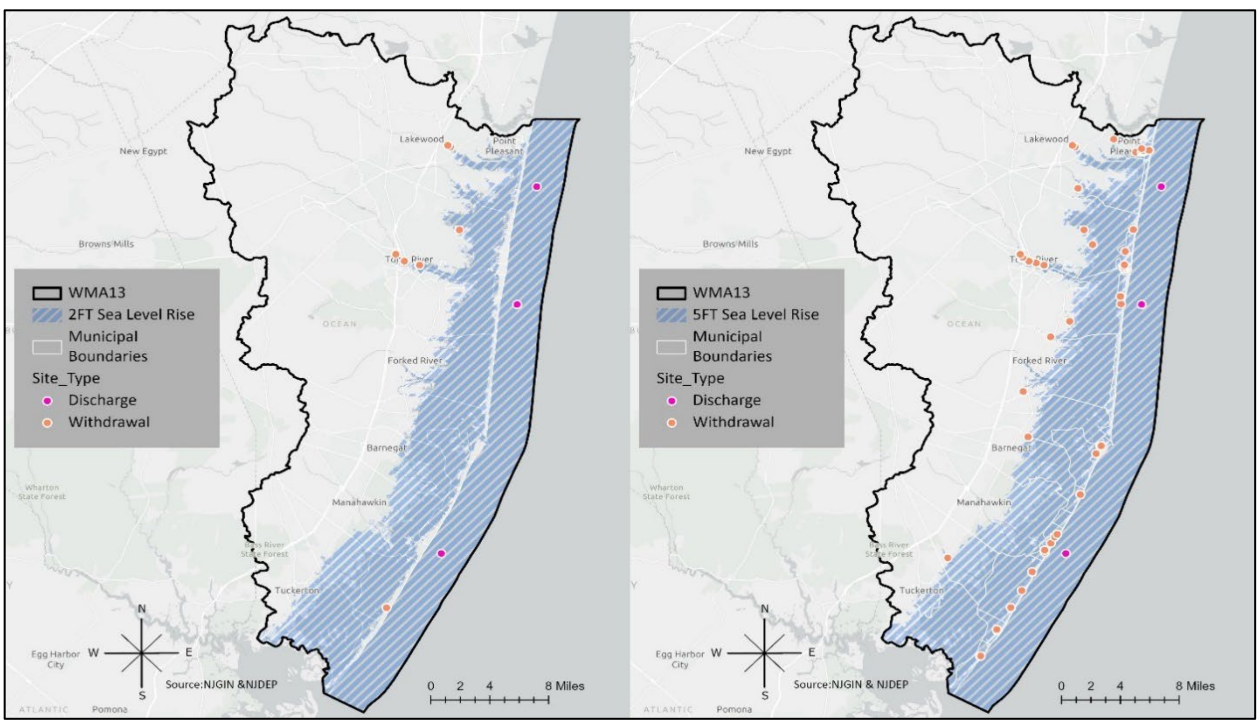

Figure I14. (Left) Map of the WMA 13 Region with 2ft of Sea Level Rise and Withdrawal and Discharge Sites with Use (between 2016-2020) That Would Be Inundated by 2ft of Sea Level Rise; (Right) Map of the WMA 13 Region with 5ft of Sea Level Rise and Withdrawal and Discharge Sites with Use (between 2016-2020) That Would Be Inundated by 5ft of Sea Level Rise

Figure I14 shows where withdrawal and discharge permit sites would become inundated under 2ft and 5ft sea level rise scenarios. Sites further inland become inundated as sea level rises in the 5ft scenario. Examining how many withdrawal and discharge permit sites are inundated by sea level rise scenarios is an important component to understanding threats to WMA 13's water supplies. As sites become inundated, they may become unusable from saltwater intrusion.

PUBLIC COMMUNITY WATER PURVEYOR SERVICE AREAS

Another threat to WMA 13's water supply is the service area of public community water systems that would be inundated by sea level rise. If PCWS service areas become inundated, water supplies may be impacted, communities may be hard to access, and purveyors' infrastructure could be at risk. A GIS analyses was performed that calculated the total area of purveyor service areas inundated by 2ft and 5 ft sea level rise. Under both scenarios, 35 PCWS service areas will experience at least some inundation and 10% of all service areas. When sea level rose to 5ft, the total percentage of PCWS service areas that will experience at least some inundation rose to 21% (see Table I17) of the total service area in WMA 13. Figure I15 shows how PCWS service areas (orange) become more inundated in 2ft (green) and 5ft (pink) sea level rise scenarios.

Sea Level Rise	Number of PSA Inundated	Percent of total PSA Inundated
2ft	35	10%
5ft	35	21%

Table I17. PCWS Services Areas in WMA13 That Would Be Inundated by 2ft and 5ft of Sea Level Rise

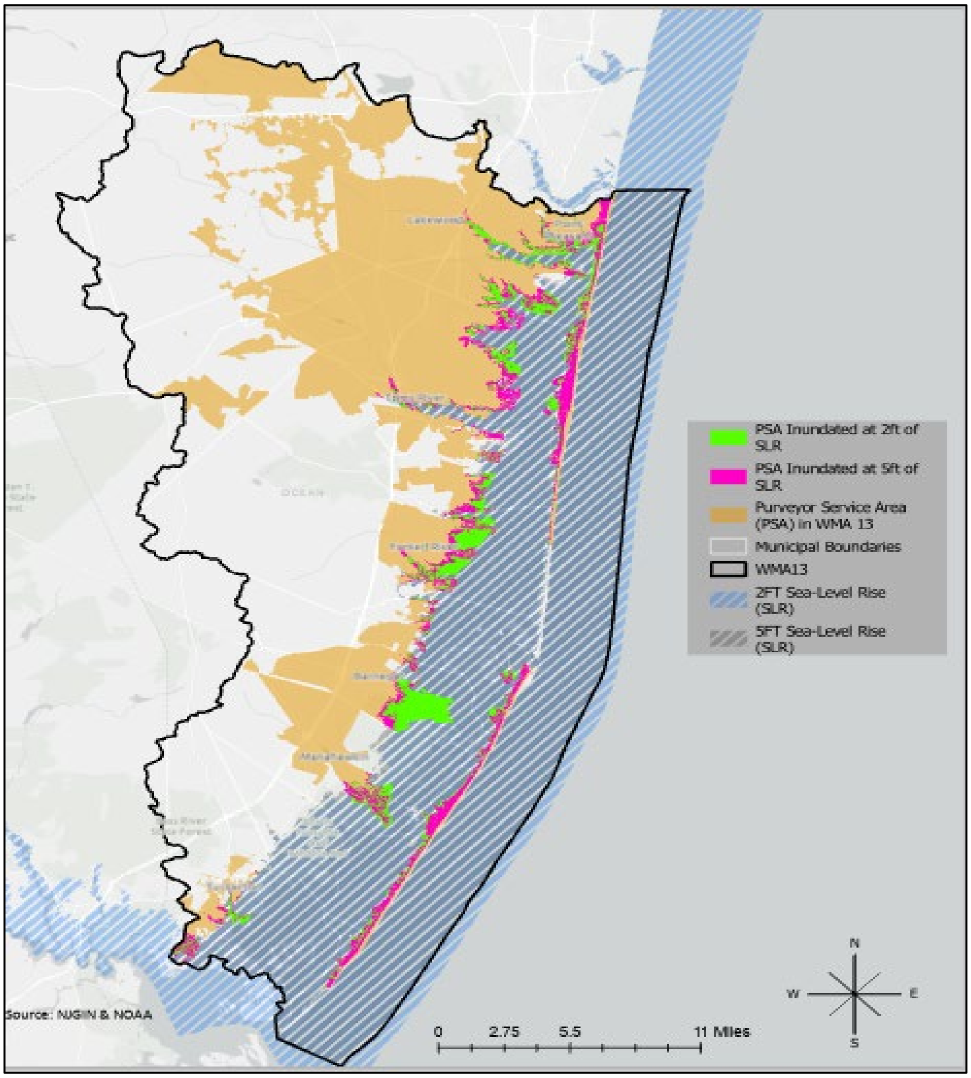

Figure I15. Map of the WMA 13 Region with 2ft of SLR, 5ft of SLR, Public Community Water Purveyor Service Areas (Orange), and the Area That Would Be Inundated by 2ft of SLR (Green) and the Area That Would Be Inundated by 5ft of SLR (pink)

Out of the 35 PCWS systems that would be inundated by 2ft and 5 ft sea level rise, there are 9 PCWS that serve the municipalities of focus in this report (see Table I18).

Sea Level Rise	Name of Purveyor in Municipalities of Focus that Experience Inundation	Percent of PSA Inundated by 2ft of SLR Compared to its Total Area	Sea Level Rise	Name of Purveyor in Municipalities of Focus that Experience Inundation	Percent of PSA Inundated by 5ft of SLR Compared to its Total Area
2ft	Aqua NJ-Eastern Division (NJ1505002)	6%	5ft	Aqua NJ-Eastern Division (NJ1505002)	15%

Sea Level Rise	Name of Purveyor in Municipalities of Focus that Experience Inundation	Percent of PSA Inundated by 2ft of SLR Compared to its Total Area	Sea Level Rise	Name of Purveyor in Municipalities of Focus that Experience Inundation	Percent of PSA Inundated by 5ft of SLR Compared to its Total Area
2ft	Barnegat Township (NJ1533001)	25%	5ft	Barnegat Township (NJ1533001)	29%
2ft	Brick Township MUA (NJ1506001)	14%	5ft	Brick Township MUA(NJ1506001)	23%
2ft	Berkeley Township (NJ1505004)	13%	5ft	Berkeley Township (NJ1505004)	27%
2ft	Lakewood Township MUA (NJ1514002)	<1%	5ft	Lakewood Township MUA(NJ1514002)	<1%
2ft	NJ American Company-Coastal North (NJ1345001)	5%	5ft	NJ American Company-Coastal North (NJ1345001)	12%
2ft	Ocean Township Department of Utilities (NJ1520001)	8%	5ft	Ocean Township Department of Utilities (NJ1520001)	22%
2ft	Shore Water Company (NJ1505003)	10%	5ft	Shore Water Company (NJ1505003)	41%
2ft	Toms River (NJ1507005)	3%	5ft	Toms River (NJ1507005)	23%

Table I18. PCWS That Serve Focus Municipalities and Would Experience Some Inundation at 2ft and 5ft SLR (Source: NOAA, NJDEP, 2023)

9.3 WMA 13 OVERBURDENED COMMUNITIES & SEA LEVEL RISE

In WMA 13, several municipalities defined as overburdened are at risk of sea level rise in WMA 13.

When sea level rises 2ft, 15 census block groups are partially indundated inundated in 13 different municipalities. When sea level rises 5ft, 18 census blocks are partially inundated, in 15 different municipalities. Census blocks groups from the municipalities of focus in this report represent 40% of census block groups in both scenarios that would be inundated in 2ft and 60% of the overburdened census block groups in 5ft sea level rise scenarios.

Figure I16 shows which census block groups become inundated under both scenarios. In both scenarios, communities inundated met either the low-income or minority definition of overburdened defined by the law.

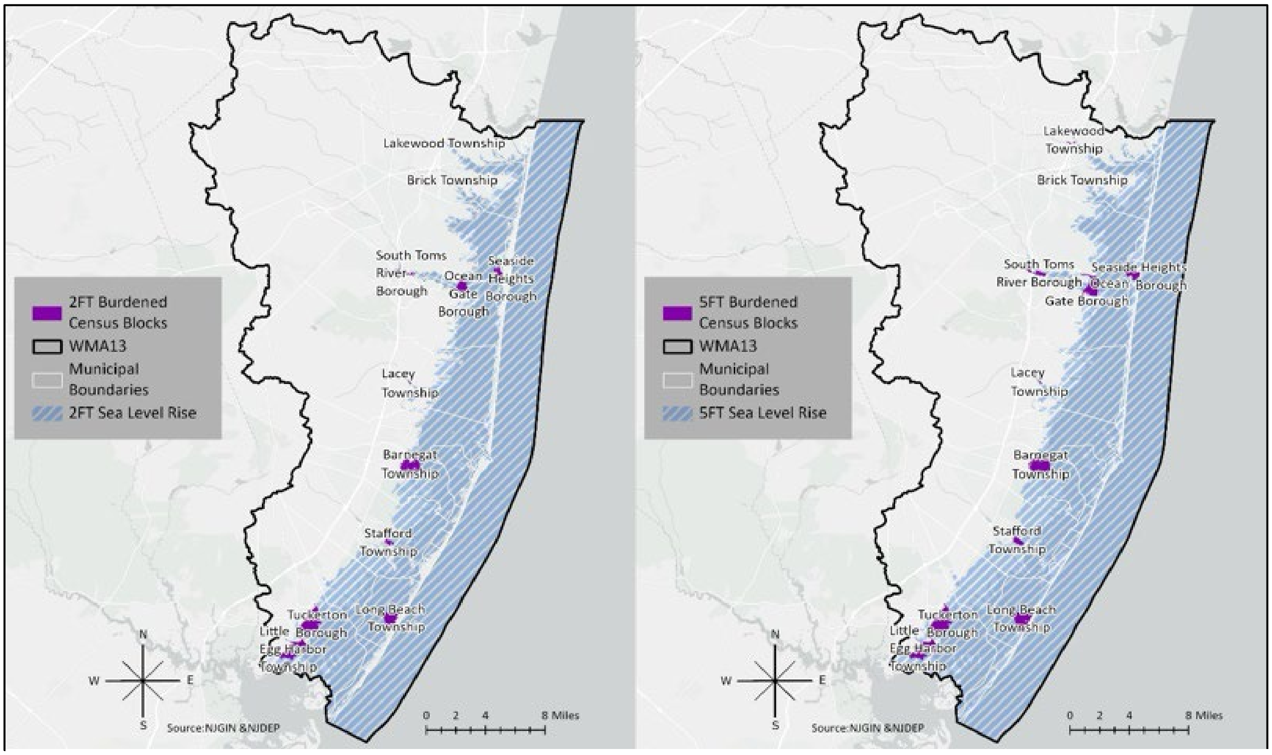

Figure I16. (Left) Map of the WMA 13 Region with 2ft of Sea Level Rise and Overburdened Census Block Groups Designated by New Jersey's Environmental Justice Law; (Right) Map of WMA 13 Region with 5ft of Sea Level Rise and Overburdened Census Block Groups Designated by New Jersey's Environmental Justice Law

Understanding which communities may be at risk of sea level rise inundation is an important consideration for municipalities. These communities may need more assistance leaving during flood events and emergency programming may need to develop communication resources in multiple languages.

CONCLUSION OF CLIMATE CHANGE AND ITS THREAT TO WMA13'S WATER SUPPLY

This discussion has considered some of ways climate change will affect WMA 13's water supplies. Under 2ft and 5ft sea level rise scenarios, water withdrawal and discharge sites in WMA 13 will become inundated. PCWS service areas will become inundated. And census block groups defined as overburdened will become inundated. This is not an exhaustive list.

Further consideration may include:

- the number of acres of aquifers and aquifer outcrop areas inundated by sea level rise;
- public infrastructure inundated by 2ft and 5ft sea level rise at WMA 13; and
- non-public community supply wells inundated by 2ft and 5ft sea level rise.

Sea Level Rise	Number of Census Block Groups Inundated	Number of Census Block Groups Inundated in Focus Municipalities
2ft	15	6
5ft	18	11

Table I19. Number of Overburdened Census Block Groups Inundated by 2ft and 5ft of Sea Level Rise (Source: NOAA, NJDEP, 2023)

10. MANAGEMENT OPTIONS

Based on population projections, water demand, climate change and sea level rise it's evident that smart water policies are necessary to protect the water supply sources of WMA 13. Municipalities in WMA 13 will need to consider current and future development. Below are several management options for consideration regarding WMA 13's water supply.

1. **Protection of PWCS wells in areas of potential inundation**

   Wells impacted by future sea level rise and storm surge should be hardened to prevent salt water from entering the well or migrating down the casing to contaminate confined aquifers.

2. **Protection of surface water intakes**

   Low elevation water supply intakes should be studied to determine if SLR will push saltwater upriver to the location of the intake. Brick Township MUA has implemented a source water protection program since 1991 to protect its intake in Forge Pond, including consideration of potential saltwater intrusion up the Metedeconk River. Further evaluation of this and potentially other intakes is warranted.

3. **Evaluation of PCWS service area risks**

   Sea level rise of 2ft or 5ft will have major implications for the long-term viability of development, which raises concerns about the costs and viability of maintaining water service to those areas. Elevating homes will likely continue to prolong the period where residential land uses remain possible. However, sea level rise will also increase groundwater levels, including saltwater intrusion in near-shore areas. That process will place utility services (water, sewer, electricity, telecommunications) at risk before the homes themselves are no longer viable due to street flooding. Future risk management programs may also prolong the viability of near-shore development. It will be important for PCWS to begin assessing risks, asset management needs and rate impacts as near-shore development transitions from year-round housing to rental, and perhaps to consolidation or removal of some buildings in later parts of the century.

4. **Protect development that meets high water use efficiency standards**

   WMA 13's population is growing. For most municipalities in WMA 13, more housing units will be needed. New proposed housing developments should continue to consider smart low impact development, proximity to current and future flood prone areas, and other measures to minimize additional water demands in WMA 13. The issue of housing types is important in at least two ways. First, greater density can achieve increased housing units on the same amount of impervious surface, reducing stormwater management needs per household. Second, higher density housing uses significantly less water per capita than low density residential development (Van Abs et al., 2018), in part due to lower per capita outdoor water demands. Dense development with high water efficiency is very appropriate in redevelopment scenarios, where existing impervious surfaces are replaced by new impervious surfaces, but with better stormwater management. Dense development should be avoided in environmentally sensitive areas.

5. **Stormwater Management and Mitigation of Recharge Losses**

Municipalities should consider establishing a stormwater program to protect and augment aquifer recharge and both ground and surface water quality, for protection of both water supplies and the Barnegat Bay. Where programs would entail significant costs, a fee-based stormwater utility may provide the most equitable method for financing those costs not supported by grants. In 2019, New Jersey signed the Clean Stormwater and Flood Reduction Act, which enables municipalities and counties to create fee-based stormwater utilities, becoming the 41st state to do so. Investing in stormwater utility strategies can protect WMA 13's water supply.

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State of New Jersey
Department of Environmental Protection

2024 NEW JERSEY STATEWIDE WATER SUPPLY PLAN

APPENDIX J

AN ASSESSMENT OF REGIONAL WATER AVAILABILITY AND DEMAND FOR WATERSHED MANAGEMENT AREA (WMA) 17: MAURICE, SALEM, AND COHANSEY RIVERS

AN ASSESSMENT OF REGIONAL WATER AVAILABILITY AND DEMAND FOR WATERSHED MANAGEMENT AREA (WMA) 17: MAURICE, SALEM, AND COHANSEY RIVERS

Jillian R. Drabik, PhD, with Chumba Koech, MCRP on GIS map preparation

August 2023

Table of Contents

EXECUTIVE SUMMARY

Watershed Management Area (WMA) 17 is located in southwestern New Jersey and includes all of Salem and Cumberland counties and portions of Atlantic and Gloucester counties. The WMA includes 19 HUC11s (eleven-digit hydrologic units), which are the basis for water availability and demand accounting. Defined by its three major rivers (Salem, Maurice, and Cohansey), this region faces water supply vulnerability, with NJDEP estimates that almost 70% of the region has demonstrated water use patterns that exceed sustainable water availability during peak consumptive/depletive loss years. This report assesses water availability and demand for the region during the planning period (2020-2050) based on factors including regional population, social vulnerability, land use patterns, surface water and groundwater availability, demand, and quality, water utilities, and projected climate change impacts. A part of this analysis included a more focused examination of specific municipalities (Carney's Point Township, Salem City, Pilesgrove Township, Vineland City, Bridgeton City, Millville City, Glassboro Borough) identified as most likely to experience either significant growth or decline based on the population analysis; these are referred to as "focus municipalities".

Regional population analysis revealed that only Gloucester County experienced population growth between 2010 and 2020, and Gloucester County is projected to significantly grow in the future. Most WMA17 counties (Salem, Cumberland, and Atlantic) had unemployment rates and poverty levels above the New Jersey state average, with clusters of socially vulnerable populations in locations including Carney's Point Township, Millville City, and Bridgeton City. WMA17 water withdrawals have been relatively stable since 2010 with predominant water withdrawals for commercial/industrial/mining purposes, and water users have relied on a roughly even split of surface water and unconfined groundwater sources. Most of WMA17's public community water systems (PCWSs) reported a decline in potable water demand between 2011-2020, and PCWS 2050 demands projections indicate that roughly half of WMA17 PCWSs will have demand decline. WMA17 communities located along the Delaware River and WMA17's three main rivers (Salem, Maurice, and Cohansey) are projected to be most vulnerable to inundation from sea level rise, with HUC11s 02040206040 and 02040206030 expected to experience the most NJDEP Bureau of Water Allocation and Well Permitting water withdrawal site inundation, followed by 02040206100 and 02040206020. Among the focus municipalities, Bridgeton City, Millville City, and Salem City are projected to have the largest number of Overburdened Community census blocks vulnerable to inundation from sea level rise.

Potential management options are provided that focus on overall WMA17 strategies and more tailored options for specific areas (see below) found to have the most significant water supply vulnerability.

Hydrologic Unit Code (HUC) 11 of Concern:

- 02040206030: Salem R (above 39d40m14s)
- 02040206080: Cohansey River (above Sunset Lake)
- 02040206180: Menantico Creek

Municipalities of Concern:

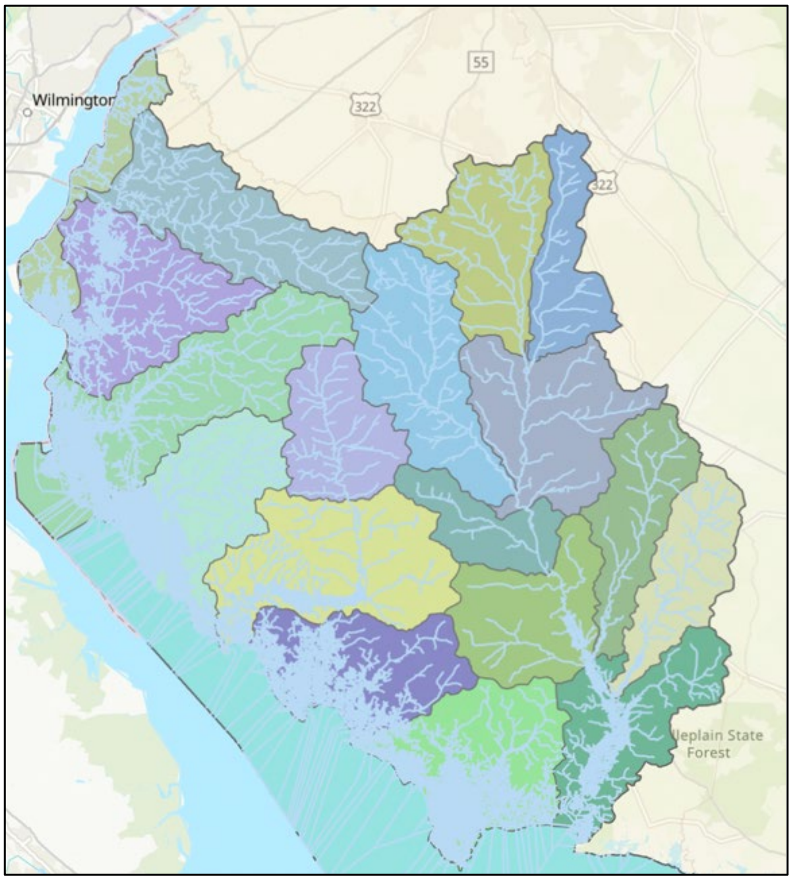
- Bridgeton City
- Salem City
- Gloucester WMA17 municipalities

Management options included encouragement of water saving strategies and improving water use efficiency, further assessment of WMA17 PCWSs to meet future regional water demand, investment to protect and restore aquifer recharge, alterations to agriculture BMPs, and investment in resilience and mitigation strategies to reduce/prevent inundation of PCWS service areas from sea level rise.

1. INTRODUCTION

Watershed Management Area (WMA) 17 is located in southwestern New Jersey and includes all of Salem and Cumberland counties and portions of Atlantic and Gloucester counties. Encompassing a total area of 1,223 square miles, WMA17 is located in the Atlantic Coastal Plain Physiographic Province.

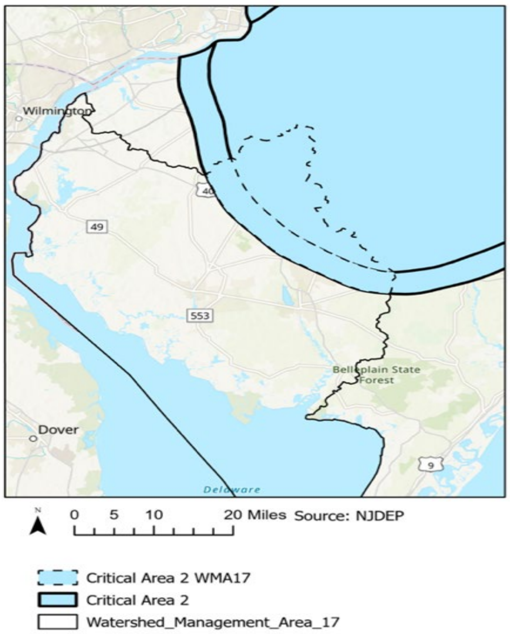
WMA17's land uses and economic development are highly reliant on its regional surface water and groundwater sources. The three major rivers in the region are the Salem, Maurice, and Cohansey rivers, which each drain into the Delaware Bay and River (Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006; NJ Division of Fish and Wildlife, 2004). Within this region, both the Delaware River and the Maurice River have been designated as critical ecological resources. Located along the western edge of Gloucester, Salem, and Cumberland counties, the Delaware River transitions into Delaware Bay. The Delaware Bayshore Area is considered a Natural Heritage Priority Site and includes critical marshland that increases coastal resilience to storm events (Cumberland County OEM & Stuart Wallace LLC, 2022). The Maurice River is considered a "Scenic Recreational River" within the U.S. National Park Service's Wild and Scenic Rivers Program, along with three of its tributaries, the Manumuskin, Menantico, and Muskee Rivers (Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006; Tetra Tech, 2022).



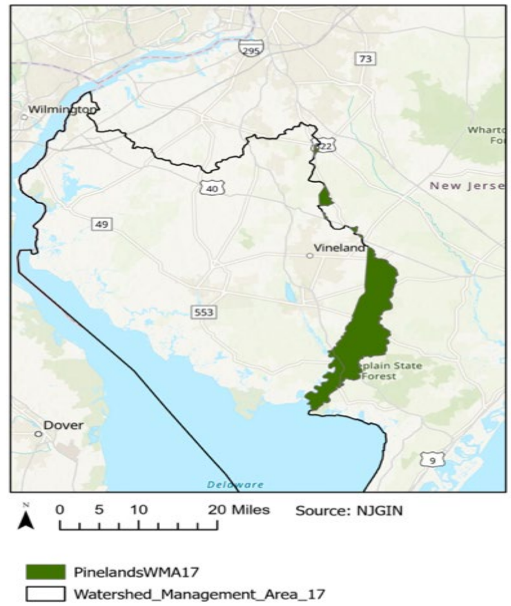
Map J1. A Map of WMA17

Several significant land and water use restrictions from Pinelands Reserve, CAFRA, and Water Supply Critical Area 2 regulations constrain WMA17's development and partially limit its water demand (See maps J2, J3, and J4). Portions of Cumberland and Gloucester counties are located within the Pinelands National Reserve and specifically within the regulatory jurisdiction of the Pinelands Commission, which regulates both land and water use within its boundaries pursuant to the Pinelands Protection Act (Cumberland County OEM & Stuart Wallace LLC, 2022; Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015; Pinelands Commission, 1981). Significant coastal areas of WMA17 are located within Coastal Area Facility Review Act (CAFRA) jurisdiction, which limits land development with regulations that become more stringent the closer the development is to the coast and environmentally sensitive areas (Simone Collins Landscape Architecture & Reed Group, 2011). Also, the majority of Gloucester County is located within the New Jersey Department of Environmental

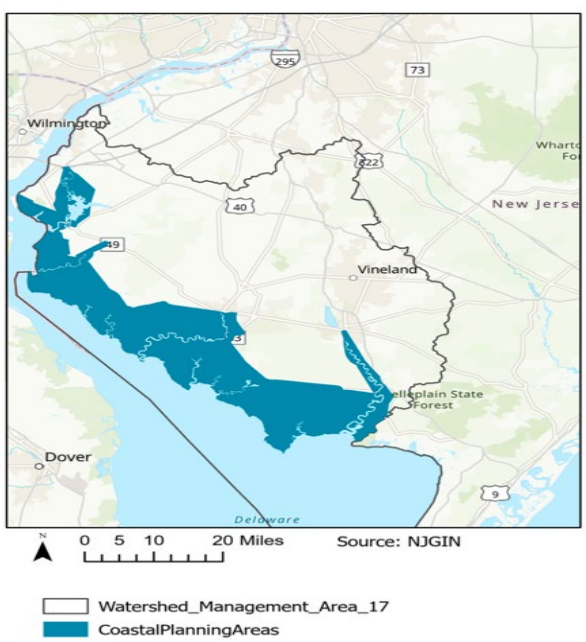
Protection's (NJDEP) Water Supply Critical Area 2, which places restrictions on regional groundwater use in the confined aquifers (Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015). With NJDEP estimating that almost 70% of WMA17's watersheds have demonstrated consumptive/depletive water use patterns during peak years that exceed sustainable surface water availability, examination of current regional water availability and demand and how they may change in the future is critical for ensuring long-term adequate water availability for the region.



Map J2. WMA17 Areas in Water Supply Critical Area 2



Map J3. WMA17 Areas Protected by New Jersey Pinelands Protection Act of 1979



Map J4. CAFRA Coastal Planning Areas in WMA17

1.1 GOALS

This assessment is part of the larger 2024 New Jersey Statewide Water Supply Plan and provides a more detailed assessment of regional water availability and demand in WMA17 for the planning period (2020-2050). This regional evaluation is Step 3 of the Framework for Regional Water Supply Planning and Management that was outlined in the 2024 Plan. It has three main goals. The first goal is to identify current water availability and demand in WMA17. The second goal is to project how water availability and demand in WMA17 may change in the future. The third goal is to identify different potential management options that can be used to reduce regional water vulnerability and deficits in WMA17.

2. METHODOLOGY

A multi-prong, multi-scale analysis was conducted to accomplish this assessment's goals. The four main components of this study (demographic analysis, water availability and demand analysis, climate change and sea level rise assessment, and development of potential management options) are described in the following sub-sections.

2.1 DEMOGRAPHIC ANALYSIS

The demographic analysis consisted of three sub-parts: population analysis (Section 4), social vulnerability assessment (Section 5), and current land use analysis (Section 6). The population analysis examined both economic and demographic characteristics of WMA17's counties and municipalities. Existing population projections for WMA17's counties and municipalities for the study planning period (2020-2050) were examined to gather better insight into which locations are anticipated to significantly change in the future. Two population projection data sources were considered for this analysis: (a) Metropolitan Planning Organization (MPO) (provided by the South Jersey Transportation Planning Organization (SJTPO) and the Delaware Valley Regional Planning Commission (DVRPC)), and (b) New Jersey Department of Labor (DOL). MPO and DOL population projections were examined and compared with 2020 Census population estimates of WMA17's counties and municipalities to determine which locations are most likely to grow or decline in the future. Municipalities considered most likely to experience a significant change in water demand due to population changes were selected for further analysis (referred to as focus municipalities).

The social vulnerability assessment focused on determining which WMA17 locations contained the most vulnerable populations. Social vulnerability was measured using two metrics, NJDEP's Overburdened Communities and the Center for Disease Control and Prevention's (CDC)'s 2018 Social Vulnerability Index (SVI). The identified vulnerable populations were considered throughout the latter sections of the study.

The current land use analysis focused on identifying current land use patterns, land development trends, and initiatives for preserving farmland and open space in WMA17. This analysis used both GIS and county and municipal documents to consider how WMA17 land use has changed over time and may change in the future. Development strategies suggested by WMA17 county planning boards, such as open space advisory committees, agricultural development boards, and economic improvement authorities were also used to consider future development trends and their impact on regional water demand.

2.2 WATER AVAILABILITY AND DEMAND ANALYSIS

The water availability and demand analysis focused on water quantity, water quality (both Section 7), and water utilities and infrastructure in WMA17 (Section 8). The water quantity section focused predominantly on data provided by NJDEP's Division of Water Supply and Geoscience (DWSG) to examine water withdrawal, discharge, and use patterns both regionally and on a smaller watershed scale (referred to as Hydrologic Unit Code (HUC) 11s). WMA17 water withdrawals were examined by both source and water use category, discharges (returns) were analyzed by source, and consumptive use was examined by water use category. Examination of WMA17 surface water vulnerability relied on the NJDEP's Low Flow Margin (LFM) method to determine which HUC11s are most stressed during their largest three-year rolling averages (peaks) of consumptive/depletive water loss. The water quality section examined surface water and groundwater sources using resources including NJDEP's 2018/2020 New Jersey Integrated Water Quality Assessment Report.

WMA17's water utilities and water infrastructure were examined using Public Community Water System (PCWS) data provided by NJDEP and county and municipal water infrastructure documents to assess how regional water demand has changed over time. 2050 water demands projections for major PCWSs servicing WMA17 were also analyzed to examine their similarities and differences with the WMA17 2050 population projections discussed in Section 4 and their implications for assessing future regional water demand.

2.3 CLIMATE CHANGE AND SEA LEVEL RISE ASSESSMENT

The climate change and sea level rise assessment (Section 9) included three sub-sections: (a) general climate change projections for the WMA17 region; (b) potential changes to WMA17 water availability due to climate change; and (c) community vulnerability to sea level rise. General climate change projections (provided by NJDEP's DWSG) for the WMA17 region are provided and projected changes to the region are discussed including inundation of water sources and NJDEP Bureau of Water Allocation and Well Permitting water withdrawal and discharge sites. Community vulnerability to sea level rise was examined by looking at purveyor service areas and Overburdened Communities at risk of inundation from two and five feet of sea level rise.

2.4 DEVELOPMENT OF POTENTIAL MANAGEMENT OPTIONS

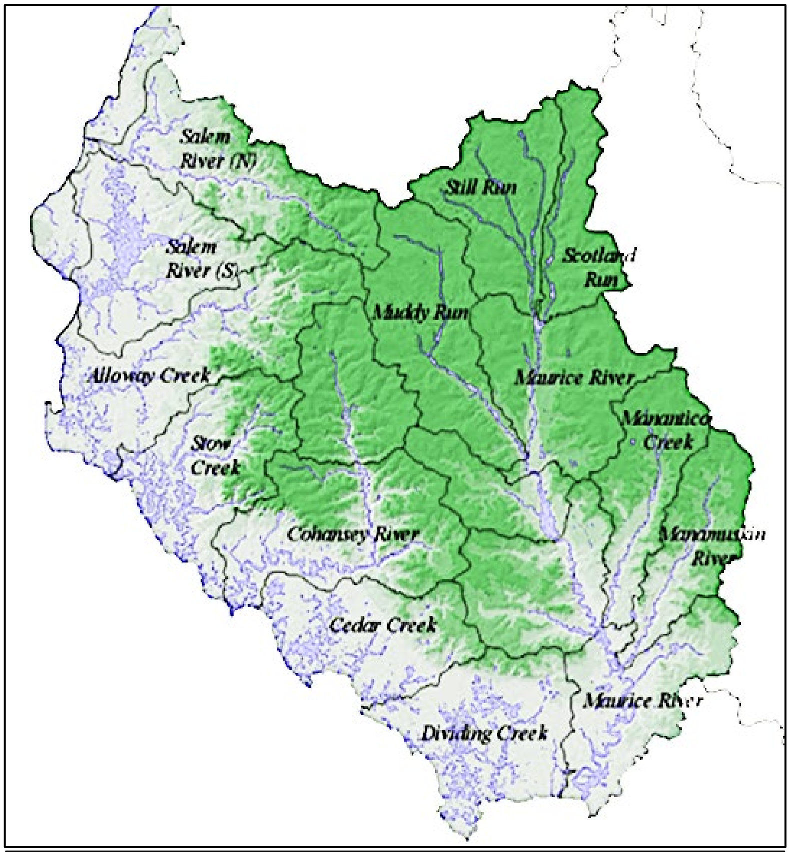
Based on the findings from the earlier sections, a list of potential management options was developed based on regional and more localized needs (Section 10). Areas considered to have the highest water supply vulnerability were identified, and management options were proposed that are tailored to address the specific needs/challenges identified in those locations.

3. WMA17 WATERBODIES

Table J1 shows all of the HUC11 watersheds in WMA17. Several watersheds (02040206130, 02040206140, 02040206180, 02040206190, 02040206200) are partially located in the Pinelands National Reserve and are subject to Pinelands Commission regulations. Seven HUC11s are located entirely or partially in Water Supply Critical Area 2 (Full: 02040206120, 02040206130; Partial: 02040206140, 02040206150, 02040206180, 02040206190).

3.1 SURFACE WATER SOURCES

WMA17's surface water sources are provided in Map J5. The Salem River drains the western part of Salem County, and runs 32 miles through Upper Pittsgrove Township, Carney's Point Township, Mannington Meadows, and Salem City before ultimately draining into the Delaware River (Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006; NJ Division of Fish and Wildlife, 2004). The Upper Salem River Watershed includes portions of Salem County's Woodstown Borough, Upper Pittsgrove Township, and Pilesgrove Township. Agriculture is considered the dominant land use in the Upper Salem River Watershed and includes cropland, pastureland, and orchards (Rutgers Cooperative Extension Water Resources Program, 2012). Major tributaries of the Salem River include Game Creek, Majors Run, and Fenwick Creek.



Map J5. A Map of WMA17 Surface Water Sources
Map courtesy of NJDEP

The Cohansey River's headwaters begin in Salem County (north of Bostwick Lake), but the watershed is primarily located in Cumberland County. Draining approximately 20% of Cumberland County, the Cohansey River travels about 27 miles before draining into Delaware Bay. The Upper Cohansey River Watershed has predominantly agricultural land use that includes sod farms, row crops, and nurseries. The Cohansey River is historically responsible for the development of Fairton, Bridgeton, and Greenwich, which remain significant development centers along the Cohansey River. For example, Bridgeton Industrial Park (located in southern Bridgeton City) is located east along the Cohansey River. Below Bridgeton's Sunset Lake Dam, the Cohansey River becomes deeper and navigable until it reaches Delaware Bay. Between Bridgeton and Fairton, the Cohansey River is straight and narrow and has a meandering pattern below Fairton (Cohansey River Planning Committee, 1998). The Cohansey River's tributaries include Harrow Run, Clarks Run, and Parsonage Run, and wetlands are located along the Cohansey River in areas including Fairton, south of Bridgeton, and near the mouth of

the river at Delaware Bay (Rutgers Cooperative Extension Water Resources Program, 2011; Cohansey River Planning Committee, 1998).

The Maurice River flows south from Gloucester County to Cumberland County, where it travels through Vineland and Millville and drains into Delaware Bay (Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006). Considered Delaware Bay's second largest tributary and the Pinelands National Reserve's western border, the Maurice River drains many of the reserve's forests along with portions of the Delaware Bay Estuary. Designated a National Scenic and Recreational River in 1993, the Maurice River's 35.5 designated miles include 10.5 miles of the main river and 20 miles of its tributaries, including all or parts of the Manumuskin River, Menantico Creek, and Muskee Creek (Sarah Birdsall Planning Consulting, 2017; Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006; Simone Collins Landscape Architecture & Reed Group, 2011). The Maurice River Watershed includes approximately 20 major lakes, including its largest lake: Union Lake in Millville City. Millville City includes the north portion of the Maurice River, spanning about four river miles and 11 river miles of its tributary, Menantico Creek (National Park Service, 2001). Tributaries that flow through Vineland to the Maurice River include Muddy Run, Still Run, and Scotland Run (City of Vineland, 2005). The Maurice River receives flow from and contributes to the Kirkwood-Cohansey Aquifer, and its watershed has unconfined aquifer use limits since the eastern Maurice River is located in Pinelands National Reserve and CAFRA protected lands (National Park Service, 2001).

HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	Pinelands	Critical Area 2	Municipalities
02040204910	Delaware Bay (Cape May Pt to Fishing Ck)	349	349			***Cumberland***: Maurice River Township, Fairfield Township, Greenwich Township, Lawrence Township, Downe Township; ***Salem***: Lower Alloways Creek Township
02040206020	Pennsville / Penns Grove tribs	14	23			***Gloucester***: Logan Township; ***Salem***: Oldmans Township, Carney's Point Township, Penns Grove Borough, Pennsville Township
02040206030	Salem R (above 39d40m14s dam)/Salem Canal	58	58			***Salem***: Oldmans Township, Carney's Point Township, Pilesgrove Township, Pennsville Township, Mannington Township, Upper Pittsgrove Township, Woodstown Borough
02040206040	Salem River (below 39d40m14s dam)	59	59			***Salem:*** Carney's Point Township, Pilesgrove Township, Pennsville Township, Mannington Township, Alloway Township, Salem City, Elsinboro Township, Quinton Township, Lower Alloways Creek Township
02040206060	Alloway Creek / Hope Creek	86	77			***Salem***: Pilesgrove Township, Upper Pittsgrove Township, Alloway Township, Elsinboro Township, Quinton Township, Lower Alloways Creek Township
02040206070	Stow Creek	55	55			***Cumberland***: Hopewell Township, Stow Creek Township, Shiloh Borough, Greenwich Township; **Salem**: Alloway Township, Quinton Township, Lower Alloways Creek Township
02040206080	Cohansey River (above Sunset Lake)	37	37			***Cumberland***: Upper Deerfield Township, Hopewell Township, Stow Creek Township, Shiloh Borough; ***Salem***: Upper Pittsgrove Township, Alloway Township
02040206090	Cohansey River (below Cornwell Run)	70	107			***Cumberland***: Upper Deerfield Township, Hopewell Township, Deerfield Township, Stow Creek Township, Shiloh Borough, Bridgeton City, Fairfield Township, Greenwich Township, Lawrence Township
02040206100	Back / Cedar / Nantuxent Creeks	51	51			***Cumberland***: Fairfield Township, Lawrence Township, Downe Township
02040206110	Dividing Creek	60	61			***Cumberland***: Downe Township, Commercial Township

HUC11	HUC11 Name	HUC11 Area (mi^2)	Watershed Area (mi^2)	Pinelands	Critical Area 2	Municipalities
02040206120	Still Run / Little Ease Run	46	46		All	***Gloucester***: Washington Township, Glassboro Borough, Monroe Township, Elk Township, Clayton Borough, Franklin Township; ***Salem***: Upper Pittsgrove Township, Pittsgrove Township
02040206130	Scotland Run	30	30	Partial	All	***Cumberland***: Vineland City; ***Gloucester***: Washington Township, Monroe Township, Clayton Borough, Franklin Township; ***Salem***: Pittsgrove Township
02040206140	Maurice River (above Sherman Ave Bridge)	57	190	Partial	Partial	***Atlantic***: Buena Borough; ***Cumberland***: Vineland City, Deerfield Township, Millville City; ***Gloucester***: Franklin Township, Newfield Borough; ***Salem***: Pittsgrove Township
02040206150	Muddy Run	58	58		Partial	***Cumberland***: Vineland City, Upper Deerfield Township, Deerfield Township; ***Salem***: Upper Pittsgrove Township, Elmer Borough, Pittsgrove Township
02040206160	Maurice River (Union Lk to Sherman Ave)	25	215			***Cumberland***: Vineland City, Upper Deerfield Township, Deerfield Township, Millville City, Fairfield Township
02040206170	Maurice River (Menantico Ck to Union Lk)	45	260			***Cumberland***: Vineland City, Maurice River Township, Millville City, Fairfield Township, Lawrence Township, Downe Township, Commercial Township
02040206180	Menantico Creek	39	39	Partial	Partial	***Atlantic***: Buena Vista Township, Buena Borough; ***Cumberland***: Vineland City, Maurice River Township, Millville City
02040206190	Manamuskin River	36	36	Partial	Partial	***Atlantic***: Buena Vista Township; ***Cumberland***: Vineland City, Maurice River Township, Millville City
02040206200	Maurice River (below Menantico Creek)	49	384	Partial		***Cumberland***: Maurice River Township, Millville City, Commercial Township

Table J1. HUC11 Information for Watershed Management Area 17
Data provided by NJDEP (Snook, Domber, & Hoffman, 2014; NJDEP Division of Water Supply and Geoscience [DWSG], 2021)

3.2 GROUNDWATER SOURCES

The Kirkwood-Cohansey Aquifer is a significant WMA17 groundwater source. Considered the largest contiguous aquifer in the U.S., it is a highly productive aquifer with a 17-trillion-gallon capacity across its multi-county range (Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006). As an unconfined (surficial) aquifer, the Kirkwood-Cohansey is composed of permeable sands and gravels and relies on recharge from surface precipitation (Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015; NJ Division of Fish and Wildlife, 2004). The Kirkwood-Cohansey Aquifer is considered Salem County's main groundwater source, providing both potable supply and agricultural irrigation water to WMA17's citizens (Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006; DVRPC, 2009; Heyer, Gruel & Associates and Michael Baker International, 2018a). The Kirkwood-Cohansey is thought to have abundant water for southern New Jersey but is considered highly vulnerable to risks from contamination from septic systems and surface sources (DVRPC, 2009). Excessive withdrawal may also harm nearby environmental resources, such as the water levels of nearby wetlands (Charles and Nicholson, 2012).

The Piney Point Aquifer is a significant confined aquifer used in WMA17, with significant water withdrawals in Buena Borough (western Atlantic County) and around Bridgeton City (Cumberland County). Flow from the overlying aquifers is a significant source of inflow for the Piney Point Aquifer, while wells and flow to underlying aquifers is a significant source of outflow (Gordon, Carleton, & Rosman, 2019; U.S. Geological Survey, [forthcoming]). Development of the Piney Point Aquifer around Bridgeton in the early 2000s led to significant well water decline in areas of Cumberland County, along with significant water loss experienced around Buena Borough wells. USGS comparisons of water levels in 49 Piney Point wells between 2008 and 2013 found 19 well water levels rose (39%), 7 remained the same (14%), and 23 declined (47%) (Gordon et al., 2019). USGS model simulations of 2040 water loss scenarios identified areas around Bridgeton City and Buena Borough wells to be at risk of experiencing significant water loss from the Piney Point Aquifer in the future (U.S. Geological Survey, [forthcoming]). The onshore part of the 250-mg/L isochlor line – the line used by NJDEP to designate limits of potable water in aquifers – extends from eastern Atlantic County southwest to northern Cape May County (Gordon et al., 2019).

The Potomac-Raritan-Magothy (PRM) Aquifer is considered a significant drinking water source in southern New Jersey, especially in Gloucester and Salem counties. Considered western Salem County's primary water source, it is considered a mostly confined aquifer that provides high quality water that can be used for multiple purposes (Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006; NJ Division of Fish and Wildlife, 2004; Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015). USGS has found the significant sources of inflow and outflow for the Upper and Middle PRM are similar and include inflow from overlying aquifers and recharge and outflow from wells and drains. The Lower PRM has significant inflow from overlying aquifers and outflow from wells (U.S. Geological Survey, [forthcoming]). Within WMA17, Gloucester County, Atlantic County, and portions of eastern Salem County are located in Water Supply Critical Area 2. Established in 1993 to protect the viability of the PRM Aquifer, the Critical Area 2 designation mandated that water withdrawals from the PRM Aquifer within the designated area be reduced by 22% (NJ Division of Fish and Wildlife, 2004; Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015). Regional water supply companies are given annual withdrawal limits for PRM extraction, and no pumping increases are allowed (Tetra Tech, 2022). USGS comparisons of 2008 and 2013 Upper, Middle, and Lower PRM well water levels have indicated a recovery of water levels, with reported increases in water levels in 84%, 78%, and 85% of wells for each aquifer layer, respectively (Gordon et al., 2019). However, USGS model simulations of 2040 water loss scenarios for the PRM Aquifer detected risk of

water loss in areas near New Jersey American Water (NJAW) Penns Grove (Carney's Point Township), Pennsville Water Department wells, and Chambers Works (Carney's Point Township and Pennsville Township) (U.S. Geological Survey, [forthcoming]). While the Upper PRM's 250-mg/L isochlor line is located in southern Gloucester County in an up-dip direction that faces the Delaware River, the Middle PRM's line bisects Salem County in the west to southern Ocean County in the east (Gordon et al., 2019).

In comparison to the PRM and Kirkwood-Cohansey aquifers, the Mount-Laurel Wenonah (MLW) Aquifer is considered to have less capacity to store and transmit water (NJ Division of Fish and Wildlife, 2004). The MLW Aquifer extends from Monmouth and Middlesex counties in the northeast to Salem County in the southwest (Gordon et al., 2019). According to USGS, significant sources of inflow for the MLW include flow from overlying aquifers and recharge, while significant sources of outflow include flow to the underlying aquifers and drains (U.S. Geological Survey, [forthcoming]). After the creation of Water Supply Critical Area 2 and its restrictions on withdrawals from the PRM Aquifer, the MLW was considered a potential alternative source and water demand from the aquifer increased (Watt & Voronin, 2006; Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015). A USGS analysis comparing 2008 and 2013 water levels from 117 MLW wells indicated increased water levels in 98 wells (84%), 4 wells stayed the same (3%), and decreased water levels in 15 wells (13%) (Gordon et al., 2019). However, USGS model simulations of 2040 water loss scenarios for the MLW Aquifer identified potential risk for significant water loss in Clayton Borough (Gloucester County) and Washington Township (Gloucester County) (U.S. Geological Survey, [forthcoming]). For the MLW Aquifer, the 250-mg/L isochlor line extends about two miles inland in southwestern Salem County (Gordon et al., 2019).

Figure J1 shows the net loss confined aquifer flow in each WMA17 HUC11 in a baseline 2013 scenario and three 2040 water use scenarios. The 2040 water use scenarios are based on the demands projections provided in Van Abs, Ding, & Pierson, 2018, and includes conservation nominal water use, conservation optimal water use, and full allocation water use scenarios. This analysis, provided by USGS in a forthcoming study, shows that net confined aquifer water loss for 2013 was highest in 02040206020, 02040206030, and 02040206120. While the extreme full allocation 2040 scenario indicates the potential for a significant increase in net aquifer flow loss in 02040206020, the other two 2040 scenarios (Optimal and Nominal) in this HUC11 along with the rest of the WMA17 HUC11s, are projected to be relatively similar to the baseline 2013 scenario (U.S. Geological Survey, [forthcoming]).

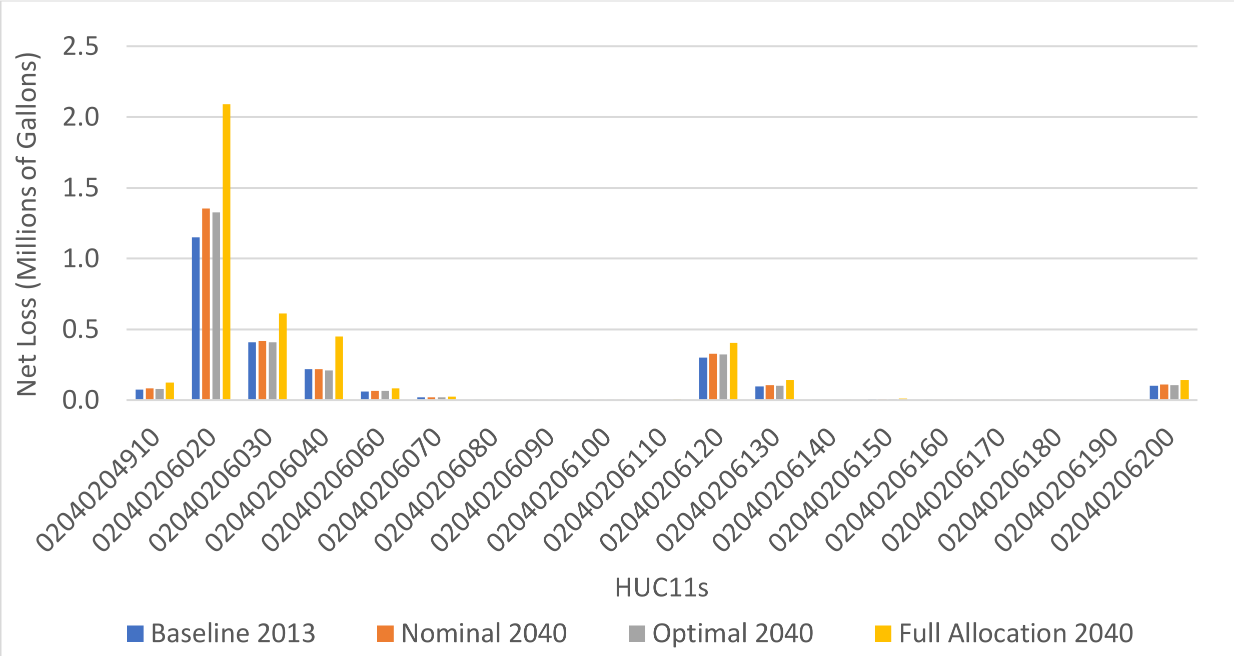


Figure J1. Net Confined Aquifer Flow in WMA17 HUC11s
Source: U.S. Geological Survey, [forthcoming]

4. DEMOGRAPHIC ANALYSIS

KEY FINDINGS

- The overall population of WMA17 municipalities grew slightly between 2010-2020. However, among the WMA17 counties (Atlantic, Cumberland, Gloucester, and Salem), only Gloucester County experienced population growth between 2010-2020.
- The projection analysis found MPO and DOL projections for WMA17 counties were similar in their forecasted time ranges, projecting growth in all WMA17 counties except Salem. Gloucester County is the WMA17 county projected to experience the most population growth.
- Seven WMA17 municipalities considered most likely to experience significant population changes (Carney's Point Township, Salem City, Pilesgrove Township, Bridgeton City, Millville City, Vineland City, and Glassboro Borough) were selected as focus municipalities for further analysis in later sections of the regional assessment.

4.1 POPULATION ANALYSIS AND INTRODUCTION TO FOCUS MUNICIPALITIES

The population analysis consisted of three components. The first two components assessed current demographic and population data for WMA17 counties and municipalities, respectively. The third component focused on the projection analysis, which examined MPO and DOL county and municipality population projections for 2020-2050 and 2019-2034, respectively. Second and third component findings were used to identify the focus municipalities used in the later sections of the assessment.

COUNTY-WIDE ANALYSIS

Table J2 provides demographic information for WMA17's counties, providing state demographic information for comparative purposes. Gloucester County was found to have the largest population and population density among WMA17 counties and was the only county to experience population growth between 2010 and 2020. This finding continues an ongoing trend of significant growth in Gloucester, as the county experienced a 13% population growth between 2000 and 2010 (Tetra Tech, 2022). Despite experiencing recent population decline, Cumberland, Salem, and Atlantic counties all grew prior to the Great Recession (Simone Collins Landscape Architecture & Reed Group, 2011; Salem County Planning Board, 2016; Heyer, Gruel & Associates and Michael Baker International, 2018a).

The economic challenges experienced by WMA17 counties can be seen from examining WMA17 county data for unemployment rate, median household income, and poverty rate. Similar to the trend with population growth, the only county to have a median household income above the New Jersey state average is Gloucester County. Salem, Cumberland, and Atlantic counties all had unemployment rates above the state average, although these values were improving from the higher rates they experienced at the start of the pandemic in 2020 (New Jersey Department of Labor and Workforce Development, 2022). Salem County's unusually large GDP per capita is likely a result of the nuclear power plants on Artificial Island. The other three counties lag New Jersey. Salem County reported a lagging economy even prior to the COVID pandemic, with estimates the county's total labor force declined from 30,900 to 30,200 between 2017 and 2019 (SJEDD, 2021). Evidence of regional economic challenges are found in Salem City, with reports of vacant buildings and buildings being used for different purposes than originally intended (LPS, 2018). Cumberland County's employment in 2020 was still approximately 6% below its peak in 2005 (Cumberland County Improvement Authority, 2020).

County	Atlantic	Cumberland	Gloucester	Salem	New Jersey
Land Area (mi^2)	556	483	322	332	7,353
2020 Real GDP (Billions of Dollars)	$11	$6	$14	$5	$536
2020 Real GDP Per Capita	$40,339	$36,922	$47,416	$78,779	$57,680
2020 Population Density (per mi^2)	494	319	939	195	1,263
2010 Census Population	274,549	156,898	288,288	66,083	8,791,894
2020 Census Population	274,534	154,152	302,294	64,837	9,288,994
Median Household Income	$63,680	$55,709	$89,056	$64,234	$85,245
Poverty Rate	14%	16%	7%	14%	10%
Unemployment Rate (May 2021 – not seasonally adjusted)	5%	5%	3%	4%	3%

Table J2. WMA17 County Demographic Information
Sources: 2020 U.S. Census (U.S. Census Bureau, 2021), 2020 ACS 5-yr estimate (American Community Survey, 2022), Bureau of Economic Analysis, 2021, NJ Department of Labor and Workforce Development, 2022

Despite being hit hard by both the 2008 Great Recession and the COVID pandemic, regional strategies have been developed for promoting economic development in WMA17. The South Jersey Economic Development District identifies several industry sectors as promising for regional economic growth: (a) tourism; (b) agriculture, food processing, and technology; (c) aviation and aeronautical industry; and (d) blue economy, including wind and clean energy (SJEDD, 2021). The fourth identified sector is related to new manufacturing and port facilities in support of Atlantic windfarms off the Jersey Coast and a proposed wind farm project (Ocean 1) in Lower Alloways Creek Township (Salem County) (Cumberland County OEM & Stuart Wallace LLC, 2022). Salem County has expressed interest in building its dominant job force sectors (which include manufacturing, education, and health, along with social service work, retail trade, and nuclear generation), and tourism development (SJEDD, 2021). Similarly, Cumberland County reported in 2020 that they felt their most promising sectors for economic growth were agriculture, education, medicine, and government, which partially aligns with their job growth trends and reported concentrations of talent among residents (Cumberland County Improvement Authority, 2020).

MUNICIPALITY-WIDE ANALYSIS

WMA17 includes all Salem County and Cumberland County municipalities, portions of seven Gloucester County municipalities (Elk Township, Glassboro Borough, Washington Township, Monroe Township, Franklin Township, Newfield Borough, and Clayton Borough), and parts of two Atlantic municipalities (Buena Borough and Buena Vista Township). Similar to the county-level analysis findings, the 2020 U.S. Census reveals many of Salem, Cumberland, and Atlantic's WMA17 municipalities experienced population decline between 2010-2020; however, the population growth among WMA17's Gloucester municipalities resulted in a slight increase in the overall WMA17 municipality population between 2010-2020. In Cumberland County, only three municipalities grew during this time period, and the only municipality to experience modest population growth was Bridgeton City. Six of Gloucester's WMA17 municipalities grew between 2010 and 2020 (only Franklin Township's population declined) (U.S. Census Bureau, 2021).

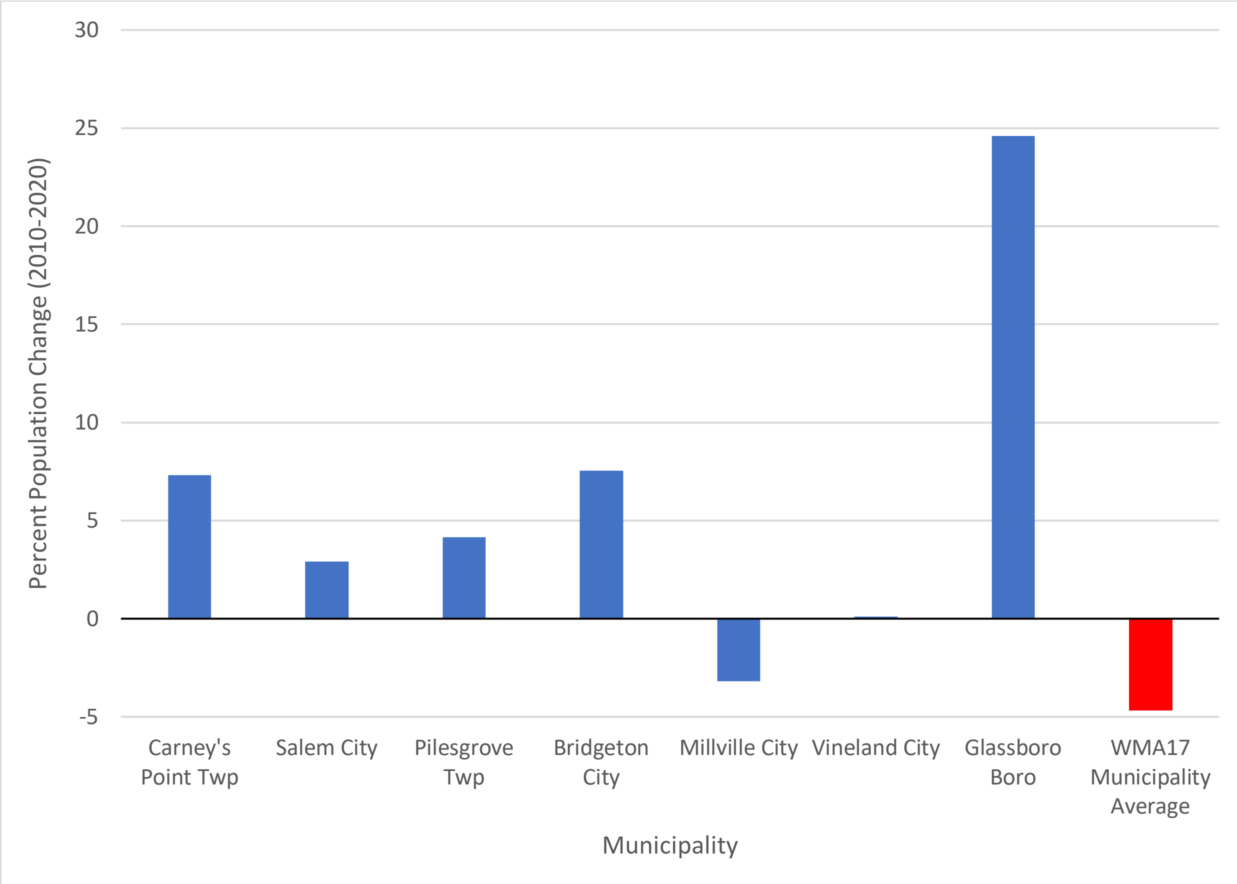


Figure J2. Percent Population Change in WMA17 Municipalities (2010-2020)

Figure J2 shows the percent population change experienced by the WMA17 municipalities selected as focus municipalities, as compared to the average percent population change of all of the WMA17 municipalities (not of WMA17's total population). Focus municipalities are municipalities identified as most likely to experience significant population changes (growth or decline) and potentially water demand changes in the future. Since many of WMA17's municipalities declined in population between 2010-2020, focus municipalities were selected based on determining municipalities either currently experiencing significant population changes or are considered the most promising for growth or decline in the future (based partially on the projection analysis in the next sub-section). Identification of focus municipalities was based on factors including municipal percent population changes between 2010-2020, examination of county planning documents, 2020 percent difference between municipal MPO projection and census population (discussed in the next sub-section), and MPO projected municipal growth through 2050 (discussed in the next sub-section).

As shown in Figure J2, many of the focus municipalities selected for analysis demonstrated growth between 2010-2020. Vineland City grew by approximately 56 people, which resulted in a small percent population change that is barely visible in the figure. Glassboro Borough, in particular, experienced the largest population growth between 2010-2020, growing by 4,570 people. Bridgeton City also grew by 1,914 people in this time period. Other municipalities, such as Carney's Point Township, Pilesgrove Township, and Salem City, experienced much smaller population growth between 2010-2020 (growing by 588, 167, and 150 people, respectively) (U.S. Census Bureau, 2021).

POPULATION PROJECTION ANALYSIS

Figure J3 shows the MPO and DOL population projections (estimates) for the four WMA17 counties. Both the MPO and DOL population projections were developed prior to the 2020 Census, and therefore are based on 2010 Census data and subsequent annual estimates. The 2020 Census results show significant differences from the earlier modeled results.

All four WMA17 counties had 2020 Census populations that exceeded their MPO 2020 projections. The Atlantic and Cumberland 2020 Census populations did not exceed their respective DOL 2019 projections, while both Gloucester and Salem did. Gloucester County is expected to experience the most population growth throughout the forecasted time ranges. The MPO forecasts Gloucester County to grow by 15,293 people by 2035 and by 35,898 by 2050. The DOL forecasts Gloucester County to grow by 20,500 people between 2019 and 2034, which is higher than the MPO forecasted growth between 2020-2035. Cumberland County, despite experiencing population decline between 2010 and 2020, is anticipated to rebound and experience population growth in both its MPO and DOL population projections, with projections to grow by 5,783 people by 2035 and 5,800 by 2034, respectively. Similarly, Atlantic County is forecasted to grow by 6,371 and 6,700 people in its MPO (2035) and DOL (2034) projections, respectively. Salem County is anticipated to decline in population in both its MPO (decline of 6,724 people by 2050 (3,317 people by 2035)) and DOL (3,200 people by 2034) population projections (SJTPO, 2021; DVRPC, 2022; DOL, 2014).

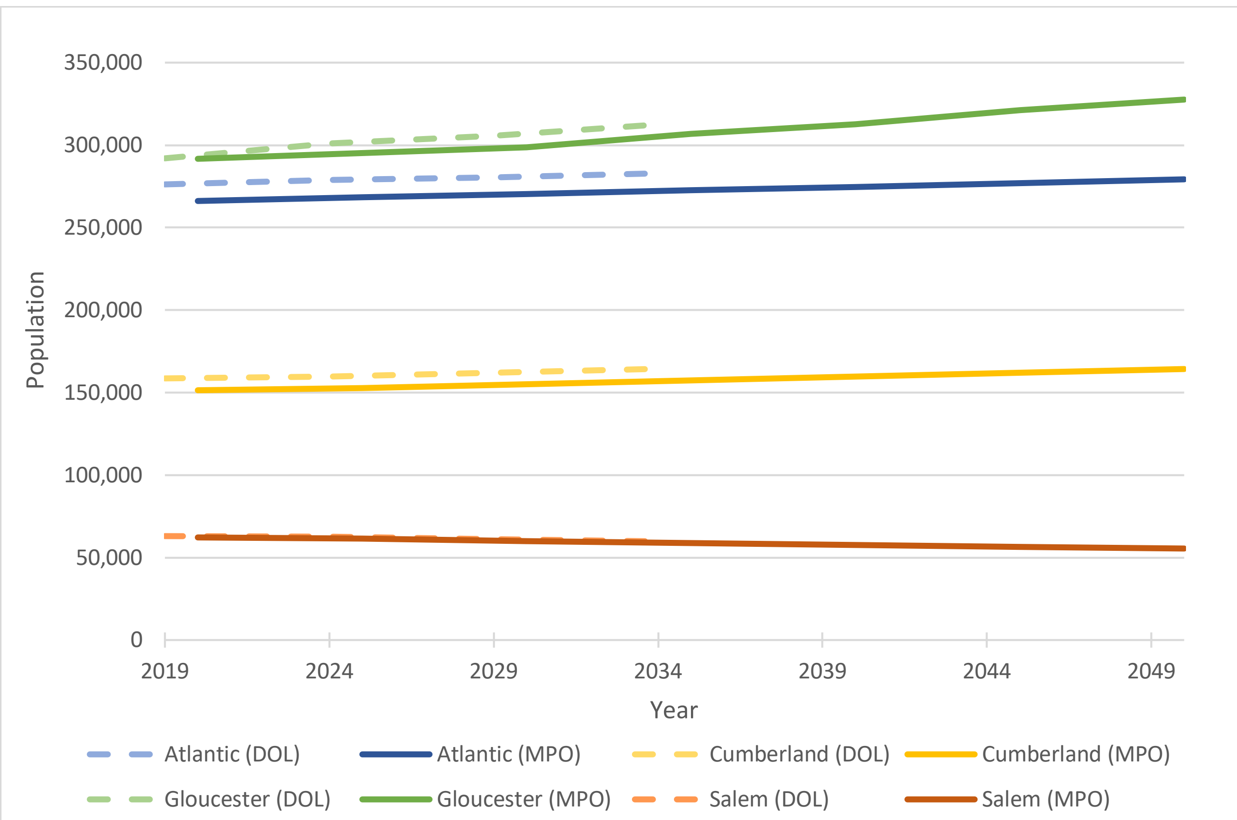


Figure J3. MPO and DOL Population Estimates for WMA17 Counties (2019-2050)

The poor outlook for Salem's population growth led to the focus municipalities selected from this county to focus on municipalities expected to experience either growth or the least amount of population loss.

Figure J4a and b demonstrate how the focus municipalities were selected for analysis. All of the municipalities selected for analysis had 2020 Census populations that exceeded their 2020 MPO population projections. Vineland and Millville City were also selected since they are projected by their MPO to have the largest population growth among the municipalities selected for analysis (SJTPO, 2021; DVRPC, 2022).

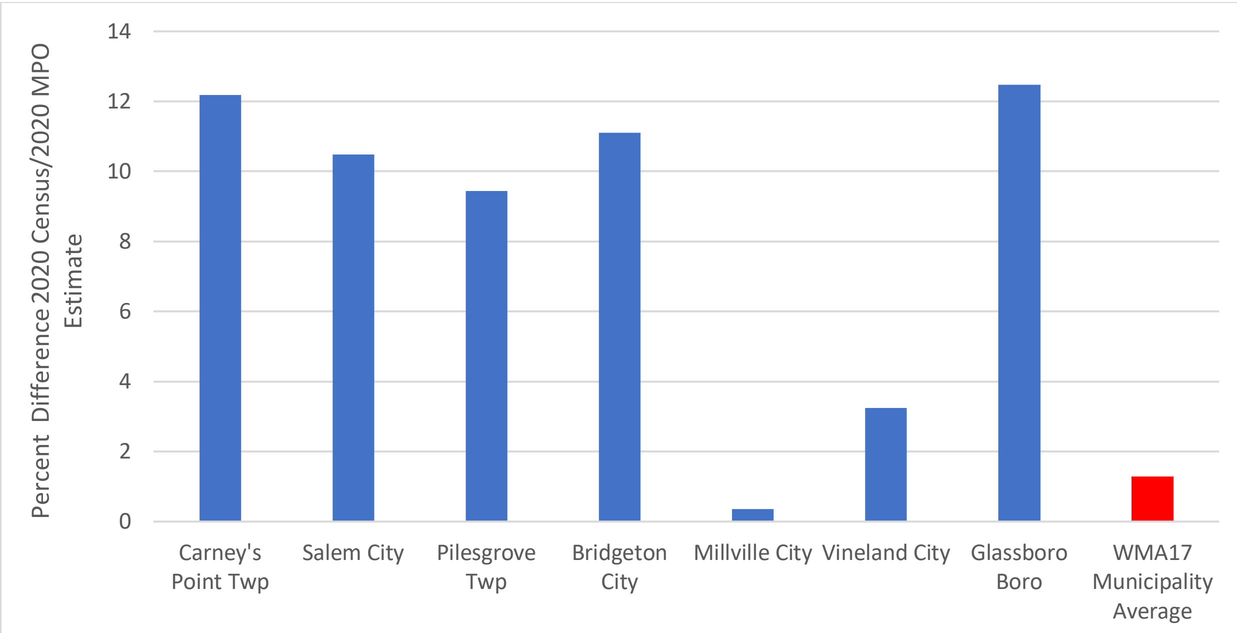


Figure J4a. Percent Difference 2020 Census Population/2020 MPO Population Estimate

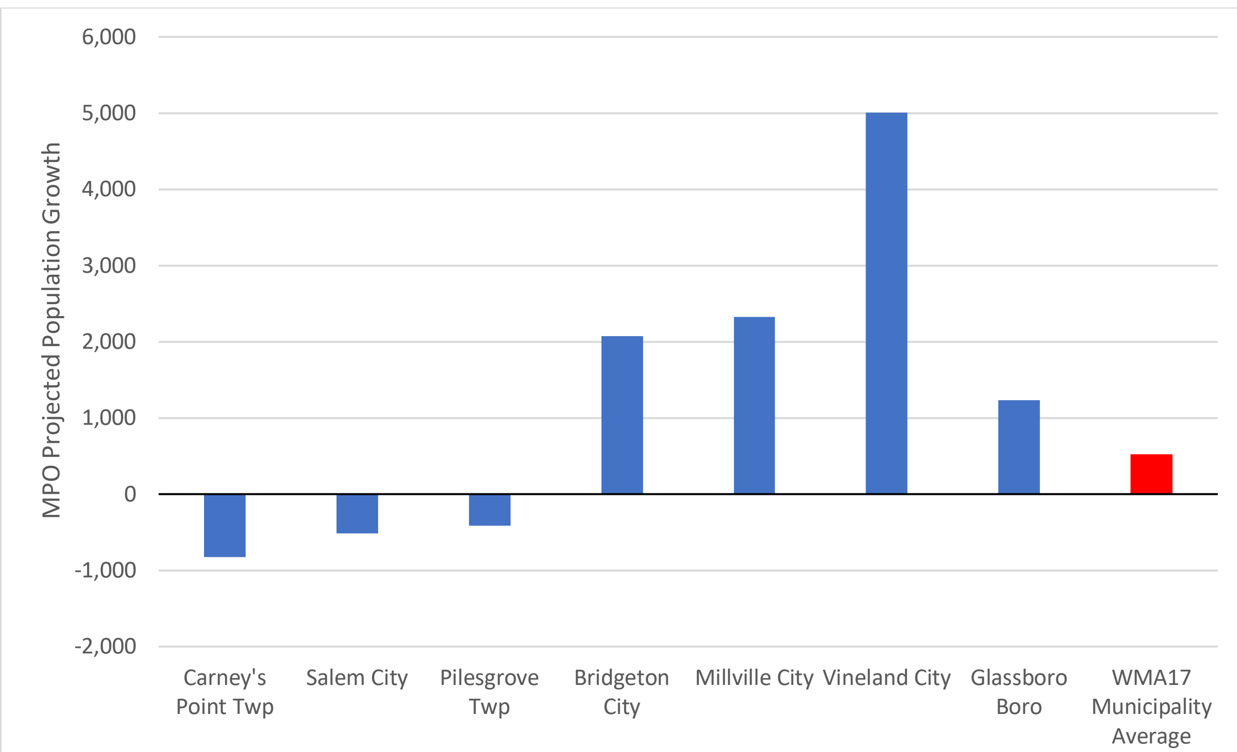


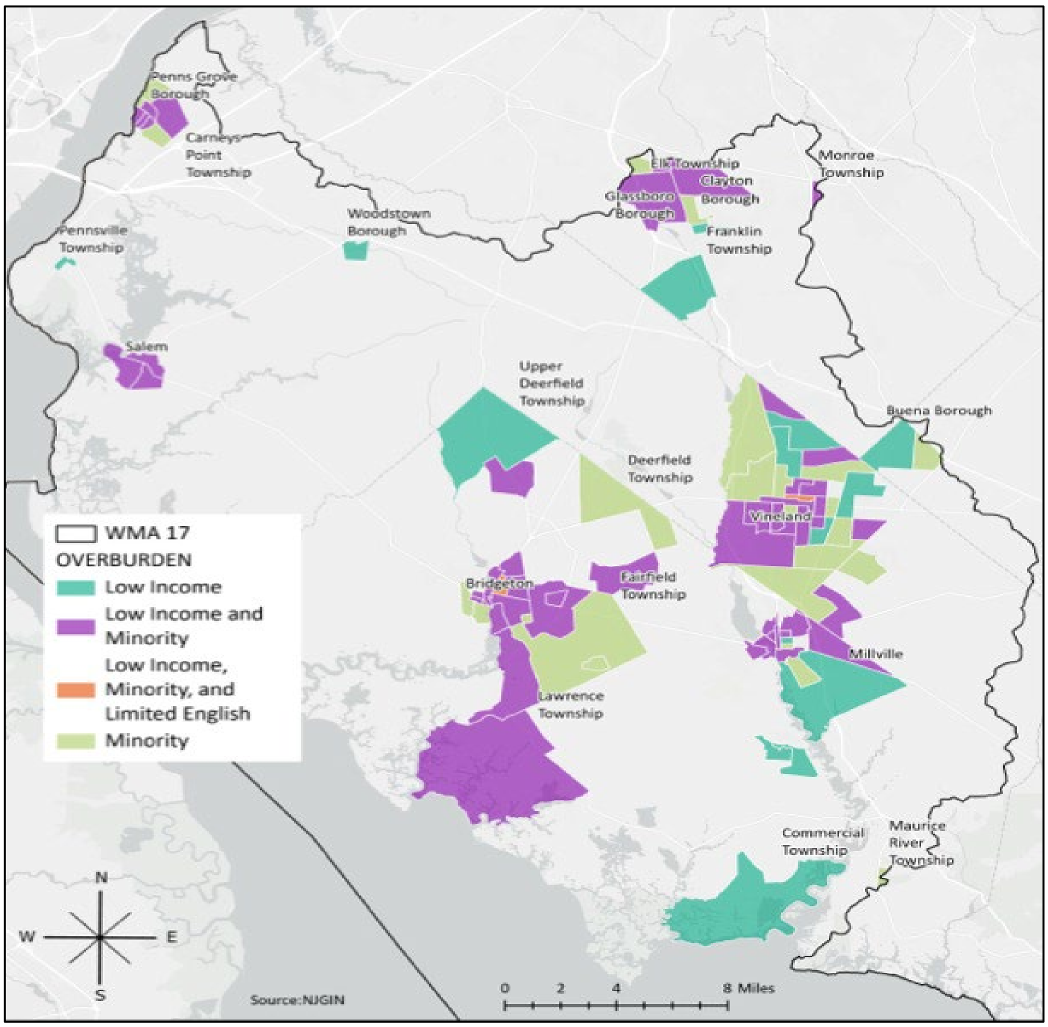
Figure J4b. MPO Projected Growth in WMA17 (2020-2050)

5. SOCIAL VULNERABILITY

KEY FINDINGS

- From examination of NJDEP's Overburdened Communities (as mapped by NJDEP under state law) and the Centers for Disease Control's (CDC's) Social Vulnerability Index (SVI) for the WMA17 region, Cumberland County was found to have the highest social vulnerability in the region.
- Although Gloucester County's SVI score suggests it has the lowest social vulnerability in WMA17, six of seven WMA17 Gloucester County municipalities contain Overburdened Communities.
- The municipalities with the largest social vulnerability include many of the focus municipalities, including Salem County's Carney's Point Township and Salem City and Cumberland County's Millville City, Vineland City, and Bridgeton City.

5.1 NJDEP OVERBURDENED COMMUNITIES



Map J6. Map of WMA17 Census Blocks Identified as Overburdened Communities

Two metrics were used to examine social vulnerability in WMA17: NJDEP's Overburdened Communities designation and CDC's SVI. On NJDEP's Office of Environmental Justice website (NJDEP Environmental Justice), Overburdened Communities are defined as:

"…any census block group, as determined in accordance with the most recent United States Census, in which:

1. at least 35 percent of the households qualify as low-income households (at or below twice the poverty threshold as determined by the United States Census Bureau);
2. at least 40 percent of the residents identify as minority or as members of a State recognized tribal community; or
3. at least 40 percent of the households have limited English proficiency (without an adult that speaks English "very well" according to the United States Census Bureau)."

County	Number of Municipalities Containing Overburdened Communities	Municipality Name
Salem	5	Carney's Point Township, Penns Grove Borough, Pennsville Township, Pittsgrove Township, Salem City
Cumberland	9	Bridgeton City, Commercial Township, Deerfield Township, Fairfield Township, Lawrence Township, Maurice River Township, Millville City, Upper Deerfield Township, Vineland City
Gloucester (municipalities in WMA17)	6	Clayton Borough, Elk Township, Franklin Township, Glassboro Borough, Monroe Township, Washington Township
Atlantic (municipalities in WMA17)	2	Buena Borough, Buena Vista Township

Table J3. Overburdened Communities in WMA17 Counties
Source: NJDEP Office of Environmental Justice, 2022

Map J6 shows the WMA17 census block groups that are designated as Overburdened Communities. As shown in the map and Table J3, Cumberland County was found to have the most WMA17 municipalities with Overburdened Communities, followed by Gloucester County. Almost all of the focus municipalities (Carney's Point Township, Salem City, Bridgeton City, Millville City, Vineland City, and Glassboro Borough) have census blocks containing Overburdened Communities.

Focus Municipality	Number of Census Block Groups Overburdened	Census Block Group Numbers	Overburdened Community Criteria in Census Block Groups
Carney's Point Township	3	340330204001, 340330204002, 340330205001	Minority, Low Income, Low Income and Minority
Salem City	3	340330219001, 340330220001, 340330221001	Low Income and Minority
Bridgeton City	12	340110201001, 340110205021, 340110202002, 340110202001, 340110203001, 340110203002, 340110204001,340110204002, 340110205031,340110205032, 340110206002,340110206003	Minority, Low Income and Minority, Low Income, Minority, and Limited English

Focus Municipality	Number of Census Block Groups Overburdened	Census Block Group Numbers	Overburdened Community Criteria in Census Block Groups
Millville City	13	340110302003, 340110304002, 340110305021, 340110301001, 340110302002, 340110302004, 340110302005, 340110303001, 340110303002, 340110303003, 340110304001, 340110304005, 340110305022	Low Income, Minority, Low Income and Minority
Vineland City	30	340110403001, 340110404002, 340110403002, 340110404003, 340110404004, 340110405001, 340110405002, 340110405003, 340110406002, 340110406003, 340110406004, 340110407002, 340110409011, 340110409012, 340110409021, 340110409024, 340110409025, 340110410002, 340110410003, 340110410004, 340110411002, 340110406001, 340110407003, 340110407004, 340110408003, 340110409022, 340110409023, 340110411001, 340110411003, 340110411004	Minority, Low Income and Minority, Low Income, Minority, and Limited English
Glassboro Borough	5	340155014021, 340155014022, 340155014023, 340155014032, 340155014061	Low Income, Minority, Low Income and Minority

Table J4. Overburdened Communities in WMA17 Focus Municipalities
Source: NJDEP Office of Environmental Justice, 2022

Table J4 describes the type of social vulnerability found in the Overburdened Communities in WMA17's focus municipalities based on NJDEP's definition of Overburdened Communities. All of these communities had census block groups with at least 40 percent of the residents identifying as minority and/or had at least 35 percent of the households qualifying as low-income households. Two focus municipalities, Bridgeton City and Vineland City, had census blocks in which at least 40 percent of their households identified as having limited English proficiency in addition to meeting the criteria for minority and low-income households.

5.2 SOCIAL VULNERABILITY INDEX

The Social Vulnerability Index (SVI) was originally created by the Agency for Toxic Substances and Diseases Registry's (ATSDR's) Geospatial Research, Analysis & Services Program to help public health officials and emergency responders identify communities most likely to require support after hazardous events. In this index, U.S. Census tracts are ranked against each other on 15 social factors (such as disability and unemployment) that are categorized into four themes (Socioeconomic Status, Household Composition and Disability, Minority Status and Language, and Housing Type and Transportation). Each tract receives a rank for each factor, each of the four themes, and overall vulnerability, which can also

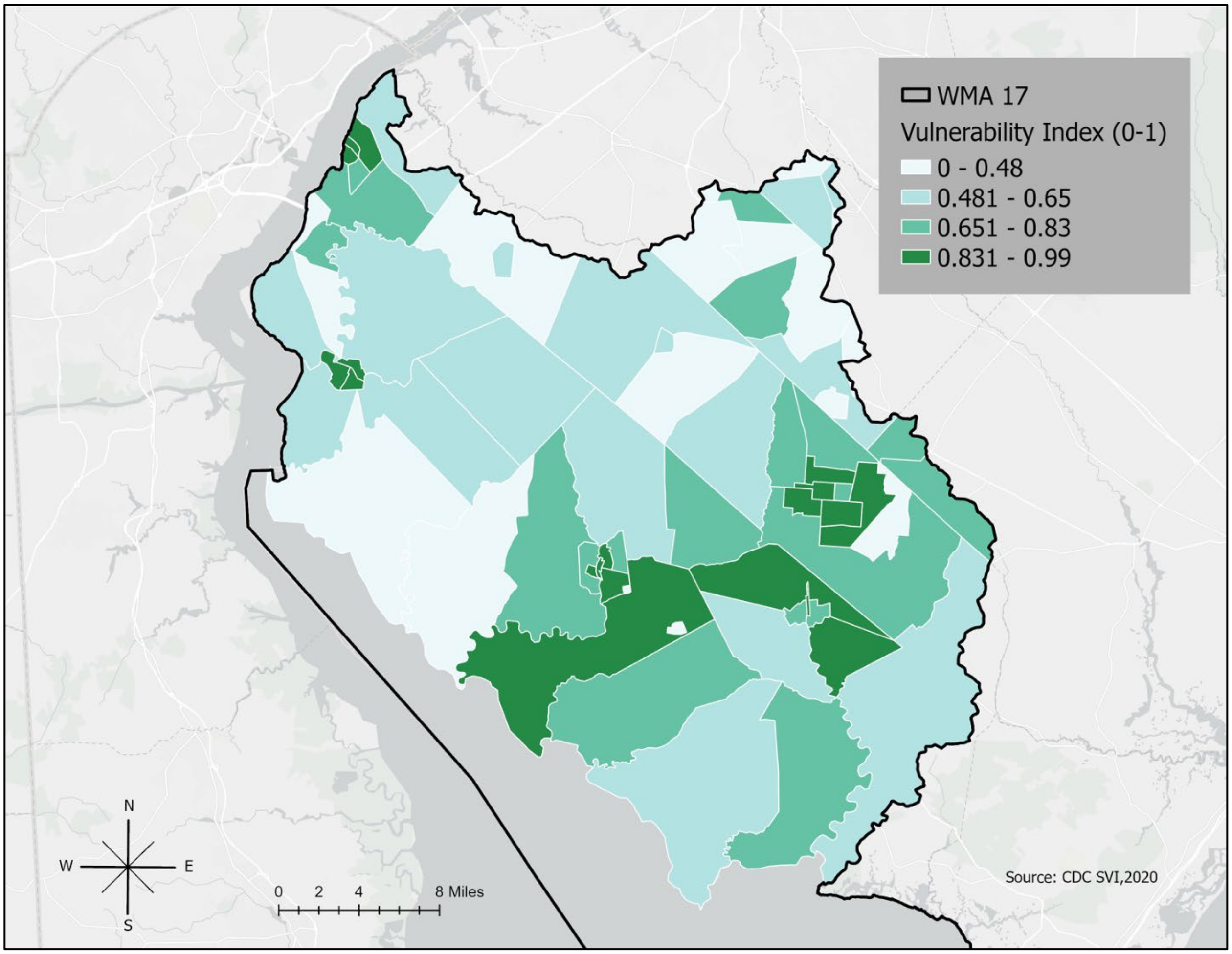
be aggregated to a county level. SVI percentile rankings are based on a score of 0 to 1, in which census-tracts (or counties) with higher values have greater vulnerability compared to other tracts (or counties) (Centers for Disease Control and Prevention Agency for Toxic Substances and Diseases Registry, 2022). In comparing the two social vulnerability metrics used in this assessment (Overburdened Communities and SVI), the Socioeconomic Status and Minority Status and Language SVI themes most closely align with the Overburdened Community metric, while the other two themes (Household Composition and Disability and Housing Type and Transportation) provide additional information about WMA17's socially vulnerable communities.

Table J5 provides the percentile ranking values for each of the major SVI categories and the Total SVI percentile rankings for each WMA17 county. These values indicate ranking against all New Jersey counties, in which 0.00 indicates the lowest vulnerability and 1.00 indicates the highest vulnerability in the state. Despite having a relatively high Composition and Disability percentile ranking (a ranking that considers single-parent households and the number of citizens aged 65 or older, aged 17 or younger, or with a disability), Gloucester County's overall SVI percentile ranking is much lower than the other three counties in WMA17. This suggests that Gloucester is the least vulnerable of the WMA17 counties. Salem, Cumberland, and Atlantic counties all have very high Socioeconomic Status percentile rankings. This category considers citizen income, the number of citizens who are living below poverty level, are unemployed, and/or have no high school diploma. Atlantic County and Cumberland County also have very high Housing Type and Transportation percentile rankings. This category considers factors such as the number of citizens living in mobile homes, group quarters, and multi-unit structures, experiencing crowding, and/or have no vehicle. Atlantic and Cumberland counties also have the highest possible total SVI percentile rankings, suggesting they are the most socially vulnerable counties in WMA17 and the state.

Among WMA17 municipalities, the highest SVI scores were located in many of the focus municipalities. The highest SVI scores were found in Salem City and parts of Carney's Point Township, Bridgeton City, Millville City, and Vineland City, followed by parts of Glassboro Borough. Other WMA17 municipalities, Penns Grove Borough and Fairfield Township, were also found to have some of the highest SVI scores in WMA17 (See Map J7).

County	Socioeconomic Status Percentile Ranking	Household Composition and Disability Percentile Ranking	Minority Status and Language Percentile Ranking	Housing Type and Transportation Percentile Ranking	Total Social Vulnerability Index Percentile Ranking
Atlantic	0.95	0.80	0.65	0.95	0.95
Cumberland	1.00	0.95	0.75	0.95	1.00
Gloucester	0.35	0.70	0.15	0.20	0.30
Salem	0.85	0.95	0.30	0.60	0.80

Table J5. Social Vulnerability Index Percentile Values for WMA17 Counties (2018)
Data courtesy of CDC ATSDR Geospatial Research, Analysis, and Services Program, 2020



Map J7. Overall SVI Scores in WMA17 (2018)

5.3 COMPARISON OF OVERBURDENED COMMUNITY AND SVI FINDINGS

Overall, SVI and Overburdened Communities results for WMA17 are consistent in identifying the region's socially vulnerable locations. SVI scores identified vulnerability in all or parts of Salem City, Carney's Point Township, Bridgeton City, Millville City, Vineland City, and Glassboro Borough, which all contain census block groups designated as Overburdened Communities. This was also consistent for Penns Grove Borough and Fairfield Township, which were identified as socially vulnerable in both metrics. Also consistent from the comparison of SVI and Overburdened Communities findings was identifying Cumberland County as the most socially vulnerable WMA17 county. Cumberland County's overall SVI score was 1.00, suggesting it is the most socially vulnerable county in the state. This vulnerability was also found in the Overburdened Community analysis, which found that Cumberland County had the most municipalities containing Overburdened Communities among WMA17 counties. Cumberland also contained two focus municipalities (Bridgeton City and Vineland City) with census block groups that met all three criteria for Overburdened Communities.

The finding that six of seven Gloucester County WMA17 municipalities contain Overburdened Communities may appear contradictory compared to its county-level SVI findings, which suggested low social vulnerability. In part, this can be a result of having only a portion of Gloucester County within WMA17. Further examination of the Overburdened Communities in Gloucester County's WMA17 municipalities reveals that the majority of the municipalities with overburdened designation is from

meeting the minority criteria followed by the low-income criteria. There were very few municipalities with census blocks that had multiple criteria met. Since the SVI scores are based on a ranking process, Gloucester County findings are interpreted as Gloucester County is the least vulnerable compared to the other WMA17 counties. However, the Overburdened Communities analysis reveals that Gloucester County contains vulnerable communities regardless of how they compare to communities in other locations. Therefore, the use of the Overburdened Community designation along with the SVI analysis helped to provide a more comprehensive picture of social vulnerability in WMA17.

6. CURRENT LAND USE

KEY FINDINGS

- WMA17 land use is dominated by water-resource areas (33% Water and 20% Wetlands), and limited, concentrated development of urban areas.
- All four WMA17 counties have a strong agricultural presence and development strategies that aim to prevent the loss of agriculture and open space.

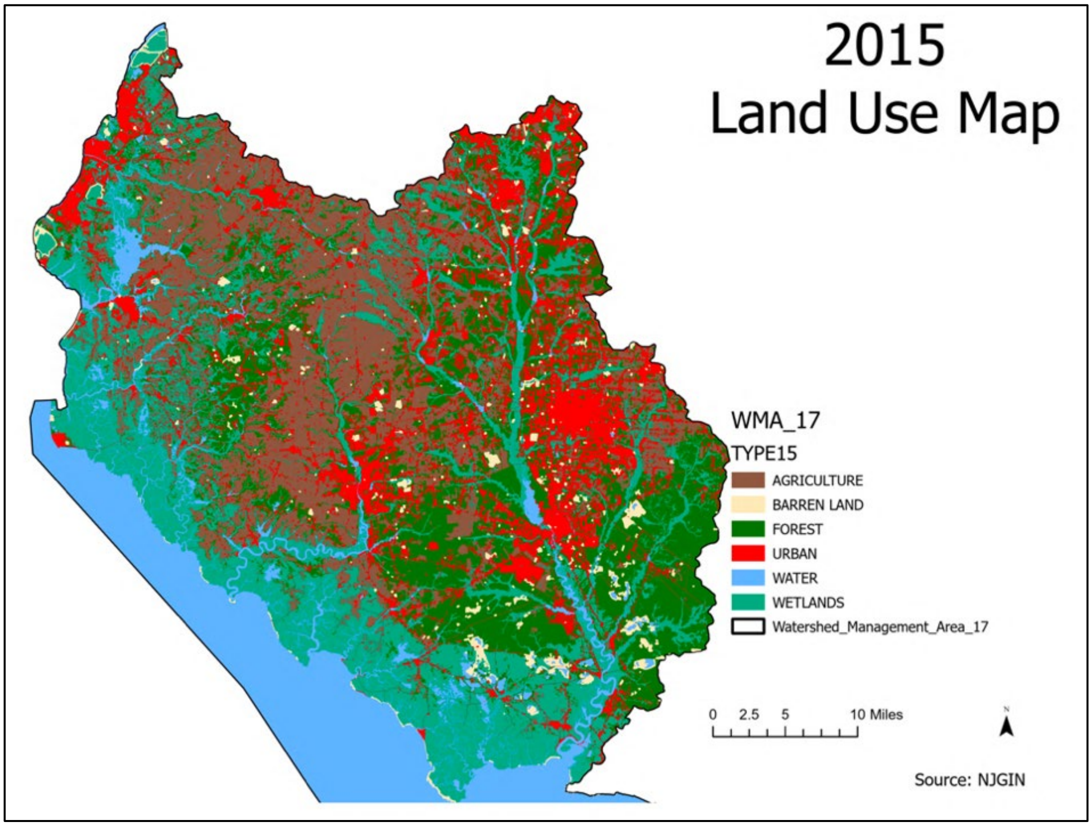
Area	Urban	Agriculture	Forest	Barren Land/ Vacant	Wetlands	Water
WMA17 Region (2015)	11%	18%	17%	1%	20%	33%
Focus Municipalities						
Glassboro Borough (2015)	44%	6%	40%	6%	*	1%
Vineland City (2012)	37%	14%	33%	2%	14%	1%
Bridgeton City (2012)	65%	2%	21%	1%	6%	5%
Millville City (2012)	28%	10%	42%	1%	13%	6%
Salem City (2012)	50%	12%	4%	2%	22%	10%
Carney's Point Township (2012)	26%	26%	14%	2%	28%	5%
Pilesgrove Township (2012)	13%	64%	12%	10%	11%	1%

Table J6. Land Use in WMA17 and Focus Municipalities
Data provided by DVRPC, 2017, Rutgers Cooperative Extension Water Resources Program (2016a, 2016b, 2016c, 2016d, 2018a, 2014) and NJDEP Bureau of GIS, 2019
*Wetlands value not provided

Table J6 provides the 2012 and 2015 land use data for the WMA17 region and its focus municipalities (Also see Map J8). As shown in the table, WMA17 has significant land use in open space, with 2015 reports of 17% forest, 33% water, and 20% wetlands land use/land cover, some portion of which has been permanently preserved. The significant portion of land use in the region in wetlands (20%) and water (33%) also demonstrates WMA17's extensive coastal area, which makes development within the region significantly influenced by the Coastal Area Facilities Review Act (CAFRA) along the coastal area. WMA17 regional approaches to concentrate development in already established towns is evident in the reported 2015 regional urban land use percentage, which is only 11%.

All four WMA17 counties have identified development strategies that rely on pre-existing development and infrastructure. Salem County is interested in promoting development in the western part of the county, which has the most population density and the most public water and sewer infrastructure (Salem County Agriculture Development Board & Salem County Open Space Advisory Committee, 2008). Since approximately two-thirds of the county's land has some type of conservation or development limitation, Cumberland County has anticipated that development will occur in Vineland, Millville, and the adjacent city limits areas of Hopewell, Upper Deerfield, and Fairfield (Cumberland County Improvement Authority, 2020; Simone Collins Landscape Architecture & Reed Group, 2011). Gloucester

County residents support the use of development strategies that infill already existing downtown areas of the county due to their concerns about loss of open space (DVRPC, 2015). Atlantic County also has planning goals designed to promote targeted growth in areas with existing infrastructure that are located outside of flood-prone areas and protect agriculture and environmental resources (Heyer, Gruel & Associates and Michael Baker International, 2018a).



Map J8. 2015 Land Use Map of WMA17

6.1 FARMLAND PRESERVATION AND OPEN SPACE

WMA17 counties have a strong agricultural presence, and many farmers have adopted water conservation practices, adopted drip irrigation, and implemented other strategies due to increased difficulties to get water allocation permits (Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015). Highlights of agricultural productivity in WMA17 counties are included below.

- **Salem County**: contains the agricultural hub, Pilesgrove Township. Known for its productive soils, Salem has strong public support for farmland preservation, despite the sector facing challenges from development encroachment, rising property value costs, and rising production and labor costs (Alaimo Group, 2012; Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006; Salem County Agriculture Development Board & Salem County Open Space Advisory Committee, 2008). The 2017 Census of Agriculture reported Salem County to have a total of 781 farms and 98,239 acres of agricultural land. The median size of farms was 25 acres, and Salem County's market value of agricultural products sold was $102,342,000.
- **Cumberland County**: Known for its production of crops including cabbage, herbs, and lettuce, the 2017 Agricultural Census reported Cumberland County had 560 farms and 66,256 acres of

agricultural land. Its median farm size was similar to Salem County's (26 acres), but its market value of agricultural products sold was larger ($212,649,000) (National Agricultural Statistics Service, 2019a; National Agricultural Statistics Service, 2019b).

- **Gloucester County**: has some of the most productive farmland in New Jersey and as of 2015, about 20% of the county was used for agricultural operations (Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015).
- **Atlantic County**: includes Buena Borough and Buena Vista Township, which both have a strong economic base for agricultural production (Heyer, Gruel & Associates and Michael Baker International, 2018a).

WMA17 counties have also made efforts to preserve their open space and reduce their impervious surfaces to increase groundwater recharge. Vineland City, Bridgeton City, and Millville City have all reported impervious surface amounts that are considered harmful to their local waterways. According to 2012 NJDEP Land Use/Land Cover data, Bridgeton, Millville, and Vineland reported 26.4%, 9.0%, and 11.4% impervious cover, respectively (Rutgers Cooperative Extension Water Resources Program, 2016b; Rutgers Cooperative Extension Water Resources Program, 2016c; Rutgers Cooperative Extension Water Resources Program, 2016a). In response to these challenges, these locations have been working to preserve open space in areas considered critical for their waterways. In 2018, Vineland was working with Millville to preserve the Menantico Creek corridor, and Vineland has acknowledged the need for continuous monitoring of the Manumuskin River, Maurice River, and Menantico Creek (City of Vineland Planning Board, 2018). Despite facing development pressure in its western areas, Atlantic County's rural areas are dominated by low density development and preserved land, and face Pinelands land use restrictions. As of 2018, Buena Borough had a total of 227.5 acres of municipal parks, and Buena Vista Township had a total of 361.4 acres of municipal parks (Heyer, Gruel & Associates, 2018).

7. WATER AVAILABILITY AND DEMAND ANALYSIS

KEY FINDINGS

- Overall WMA17 withdrawals have declined since the 1990s and have been a roughly even split between water withdrawals from surface water and unconfined groundwater sources since 2012. After 2010, commercial, industrial, and mining re-established itself as the top water use category for withdrawals, with agriculture/irrigation and potable supply as smaller, but consistent water use categories.
- WMA17's HUC11s with the largest average withdrawals between 2016-2020 include 02040206110 (Dividing Creek), 02040206030 (Salem R (above 39d40m14s dam)/Salem Canal), and 02040206180 (Menantico Creek). The largest consumptive water use in WMA17 between 1990-2020 was for agricultural/irrigation purposes.
- NJDEP Low Flow Margin data reveals six of 19 WMA17 HUC11s were unstressed during their three-year rolling averages of peak depletive/consumptive loss. The HUC11s with the largest deficits were 02040206080 (Cohansey River above Sunset Lake), 02040206150 (Muddy Run), and 02040206180 (Menantico Creek).
- The Salem, Maurice, and Cohansey rivers have all been found to suffer some water quality impairment, with elevated levels of nutrients including Phosphorus and Lead.

Figure J5a shows WMA17 water withdrawals from 1990-2020 based on water withdrawal source. Water was withdrawn predominantly from surface water sources in the 1990s, which were on average 55% of total withdrawals. A significant decline in surface water withdrawals led to the majority of water withdrawals in WMA17 to come from unconfined groundwater sources after 2002. This decline was due in large part to a mining company ceasing surface water withdrawals between 2002 and 2003 (Hanson Aggregates, a firm specializing in sand, gravel, and crushed stone). Dominant use of unconfined groundwater sources persisted throughout the early 2000s, and ultimately changed to a roughly even split between water withdrawals from surface water and unconfined groundwater sources after 2012 (NJDEP Division of Water Supply and Geoscience, 2021).

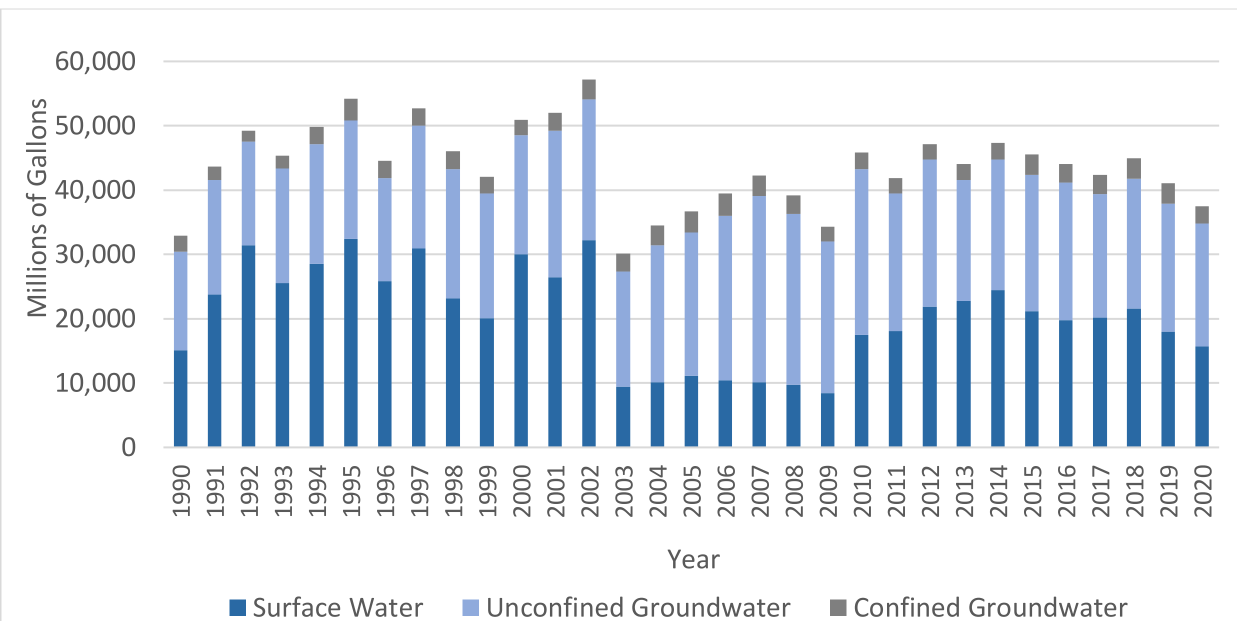


Figure J5a. WMA17 Water Withdrawals by Source (1990-2020)

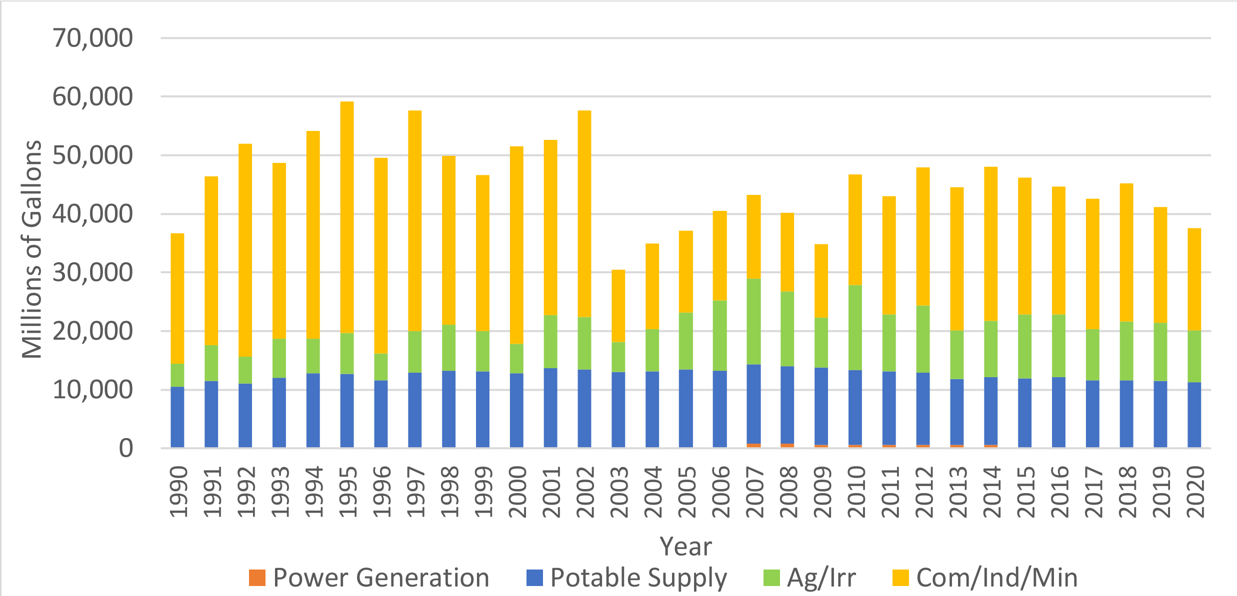


Figure J5b. WMA17 Water Withdrawals by Water Use Category (1990-2020)

As shown in Figure J5b, WMA17 water withdrawals were primarily for commercial, industrial, and mining purposes throughout the 1990s. On average, commercial, industrial, and mining withdrawals were 63% of total WMA17 withdrawals during this period, with approximately 72% of these withdrawals used for mining and 28% used for industrial purposes. Significant decline in water withdrawals after 2003 led to water withdrawals for potable supply and commercial, industrial, and mining purposes to be very similar and dominant withdrawal categories between 2003-2009. After 2010, commercial, industrial, and mining re-established itself as the top water withdrawal water use category, although water withdrawals for both potable supply and agriculture and irrigation remained significant water use categories through 2020. It should be noted that the Salem Nuclear Generation facilities use water directly from the Delaware River, as use not reflected in these graphs as this withdrawal does not affect WMA17 water availability (NJDEP Division of Water Supply and Geoscience, 2021).

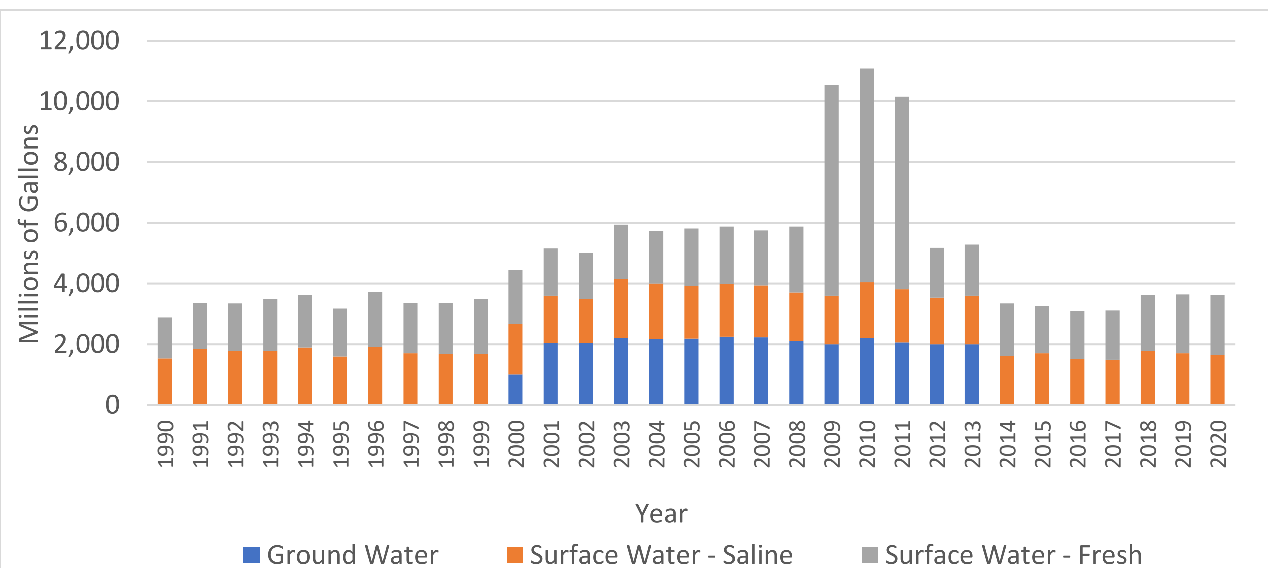


Figure J6. WMA17 Sanitary Sewer Returns by Source (1990-2020)

Figure J6 shows WMA17 sanitary sewer discharges (returns) to groundwater and surface water sources from 1990-2020. Throughout the 1990s and from 2014-2020, WMA17 discharges were only to surface water sources, which were a roughly 50/50 split to surface saline water and surface fresh water sources. Between 2000 and 2013, WMA17 discharged to groundwater sources, which varied between 19% and 41% of WMA17's total discharges in a given year. Almost all of these groundwater discharges (approximately 97%) were from Landis Sewerage Authority, serving the Vineland area. Between 2009 and 2011, WMA17's discharges to surface fresh water sources grew significantly, becoming slightly less than two-thirds of the WMA's total discharges. This sudden spike in discharges to surface fresh water sources was due to short-term discharges from the chemical manufacturing site, Dupont Chamber Works (now Chemours Chambers Works), and Seabrook Brothers & Sons Inc. (a food and vegetable processing company) during this time period (NJDEP Division of Water Supply and Geoscience, 2021).

7.1 WATER QUANTITY

Figure J7 shows the average water withdrawals for each HUC11 in WMA17 based on water use category between 2016-2020. The HUC11, 02040206110 (Dividing Creek), had the largest average water withdrawal between 2016-2020, which was slightly less than 9,400 million (9.4 billion) gallons. This water withdrawal was almost entirely for commercial, industrial, and mining purposes, with mining making up the majority (approximately 82%) of total withdrawals in this 5-year period. The HUC11s with the next largest average withdrawals were 02040206030 (Salem R (above 39d40m14s dam)/Salem Canal) and 02040206180 (Menantico Creek). While 02040206030's water withdrawals were predominantly for commercial, industrial, and mining purposes, 02040206180's water withdrawals were largely split between agricultural and irrigation (approximately 34% of average withdrawals) and commercial, industrial, and mining purposes (approximately 47% of average withdrawals). Both of these HUC11s had average withdrawals of approximately 4,476 and 3,673 million gallons for the five-year period, respectively (NJDEP Division of Water Supply and Geoscience, 2021).

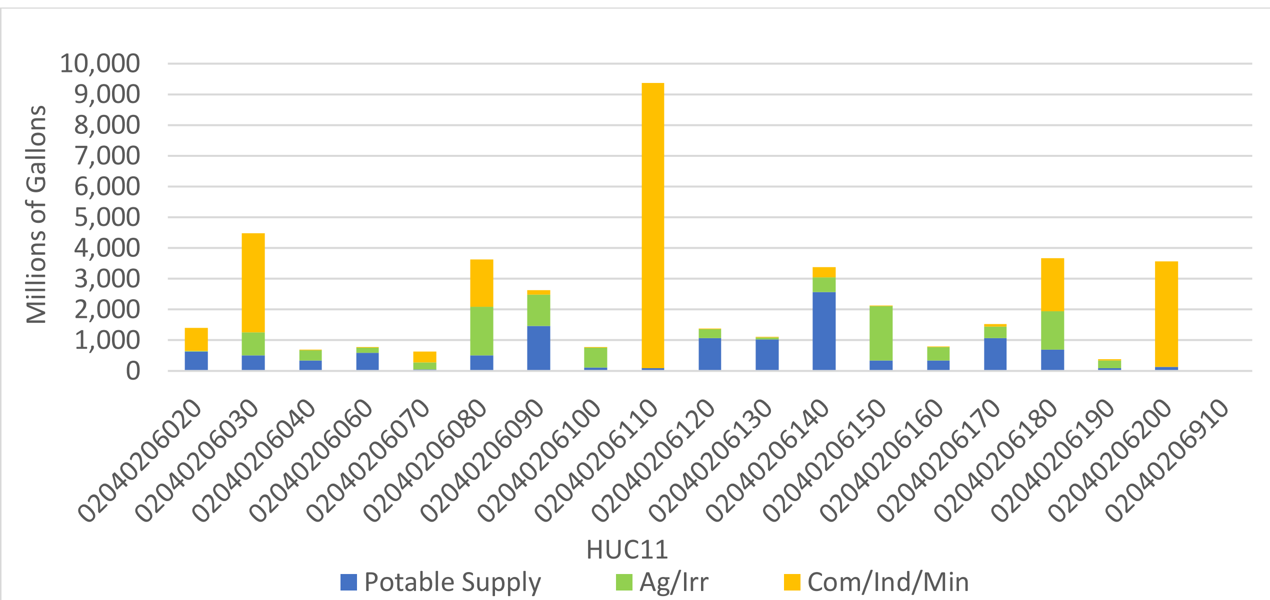


Figure J7. WMA17 HUC11 5-Year Average Water Withdrawals by Water Use Category (2016-2020)

Figure J8 provides the annual consumptive water use in WMA17 by water use category between 1990-2020. Consumptive water use is considered water that is removed from a water source, used, and ultimately lost (often through evapotranspiration processes), which can vary by water use category

(since a different percentage of water evaporates for different water uses) and in different seasons. This water use is different than depletive water use, in which water is removed from its source area and discharged in another HUC11 or tidal waters (depletive water uses are tracked separately). Therefore, Figure J8 reflects the total annual amount of water lost to each HUC11 for each water use category in WMA17 between 1990-2020 (NJDEP Division of Water Supply and Geoscience, 2021).

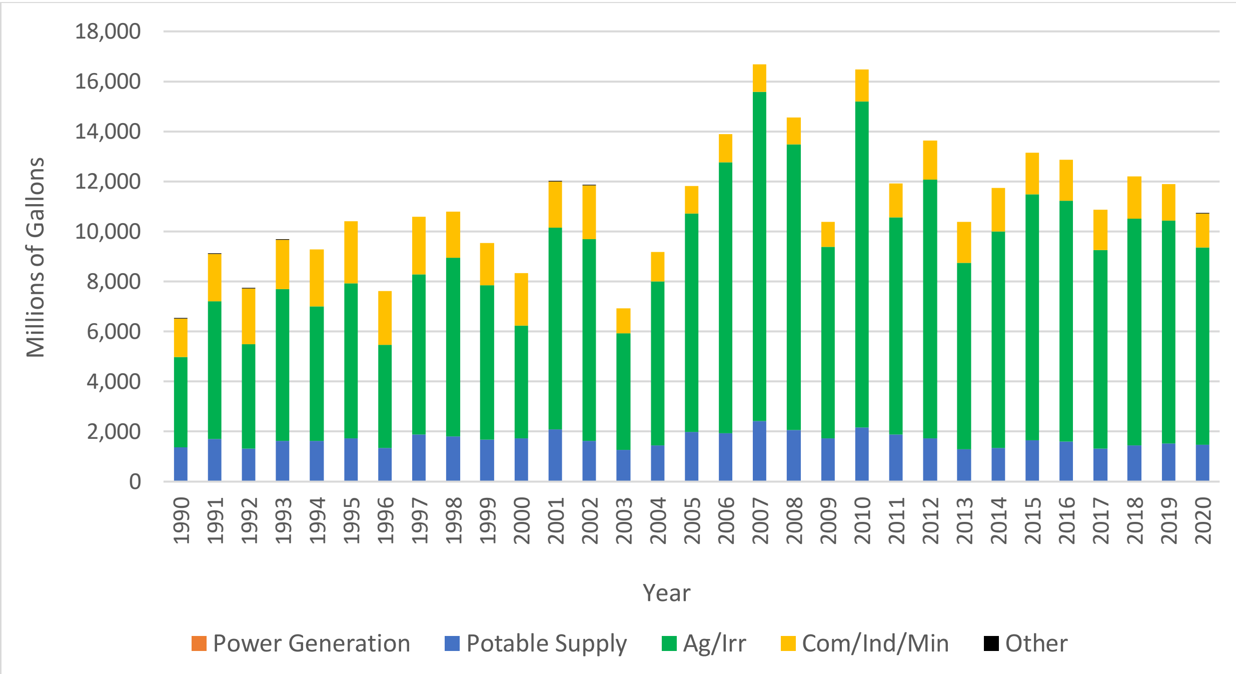


Figure J8. WMA17 Consumptive Water Use by Water Use Category (1990-2020)

As shown in Figure J8, consumptive water use in WMA17 experienced a gradual increase and decline in the time period considered. WMA17 had an average consumptive water use of approximately 9,127 million gallons a year (9.127 billion gallons a year) in the 1990s, which increased to 12,012 million gallons a year between 2000-2010, and declined to 11,938 million gallons a year between 2011-2020. Agriculture and irrigation (Ag/Irr) had the largest consumptive water use among WMA17's water use categories throughout the considered time period. Water use for the agriculture/irrigation category was almost entirely for agricultural purposes (approximately 98% between 1990-2020). In comparison to the other water use categories, most water used for agriculture evaporates with almost all of its withdrawn water being consumed (evaporated) in the summer months. Agricultural consumptive water use as a percentage of total WMA17 consumptive water use has increased over time, with agricultural consumptive water use being approximately 58% of WMA17's total consumptive water use in the 1990s and approximately 72% of WMA17's total consumptive water use between 2000-2020 (NJDEP Division of Water Supply and Geoscience, 2021).

Figure J9 provides monthly consumptive water use data for WMA17 by water use category between 2005-2020. Similar to the overall consumptive water use for WMA17, agriculture/irrigation had larger consumptive water use between 2005-2010 (approximately 10,818 million gallons a year) compared to 2011-2020 (approximately 8,838 million gallons a year). The large peaks for agriculture/irrigation show the significant seasonality of consumptive water use for this water use category, in which the largest consumptive water use is experienced in the summer months. Agriculture/irrigation experienced its highest peaks in July 2007 (approximately 3,311 million gallons) and July 2010 (approximately 3,021 million gallons) (NJDEP Division of Water Supply and Geoscience, 2021).

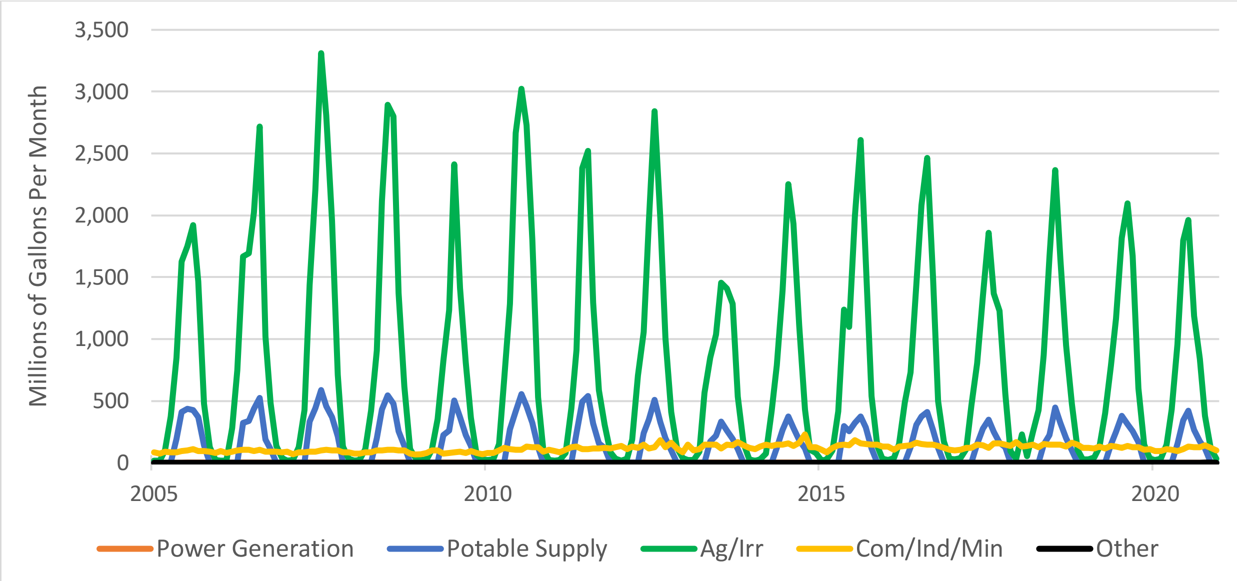


Figure J9. WMA17 Monthly Consumptive Use by Water Use Sector (2005-2020)

In comparison, consumptive water use for potable supply in WMA17 also experienced seasonal peaks in summer months, but on a much smaller scale. Overall consumptive water use for potable supply has also declined over time, with potable supply having an average consumptive water use of approximately 2,039 million gallons a year between 2005-2010 and 1,524 million gallons a year between 2011-2020. Consumptive water use for commercial/industrial/mining purposes did not show a seasonal effect and had consistent consumptive water use throughout the year. However, consumptive water use for this water use category increased gradually over time, with an average consumptive water use of approximately 1,109 million gallons a year experienced between 2005-2010 and 1,574 million gallons a year experienced between 2011-2020 (NJDEP Division of Water Supply and Geoscience, 2021).

LOW FLOW MARGIN METHOD

NJDEP uses the streamflow Low Flow Margin (LFM) method to consider what HUC11s are or may be stressed based on their largest three-year running average (peaks) in consumptive/depletive water loss, regarding use of the unconfined (surficial) aquifer and surface waters (confined aquifers are addressed separately). Figure J10a and b show the amount of available water used in each HUC11 during their peak three-year average loss intervals between 2011-2020. In both figures, the only HUC11 with net gain in WMA17 (02040206020-Pennsville/Penns Grove tribs), is indicated in green in both figures. Any HUC11 with depletive/consumptive loss greater than 100% water available is indicated in red and is considered potentially vulnerable or stressed.

As shown in the figures, six out of 19 WMA17 watersheds are considered unstressed (although two HUC11s have such little water remaining, it is barely or not visible in Figure J10b). Within WMA17, the agriculture and irrigation water use category was identified as the largest source of consumptive/depletive loss, which was identified in 11 of 19 HUC11s. Potable supply was the second largest source of consumptive/depletive loss among WMA17 HUC11s (found in four HUC11s). Of the 13 stressed HUC11s, nine HUC11s had agriculture and irrigation as their largest source of depletive/consumptive loss (compared to three HUC11s for potable supply).

Notice that the negative HUC11s in Figure J10b are more negative than the positive HUC11s are positive, indicating WMA17's vulnerability to stress during periods of peak water loss. The HUC11s considered

most stressed are 02040206080 (Cohansey River above Sunset Lake) and 02040206150 (Muddy Run), followed by 02040206180 (Menantico Creek) and 02040206030 (Salem R(above 39d40m14s dam)/Salem Canal). The agriculture and irrigation water use category was the largest source of consumptive/depletive loss for all four of these HUC11s (NJDEP Division of Water Supply and Geoscience, [forthcoming]). However, as discussed in the 2024 Plan, the tracking of agricultural demands has been an ongoing issue, with the potential for both overcounting and undercounting of water withdrawals and of consumptive losses.

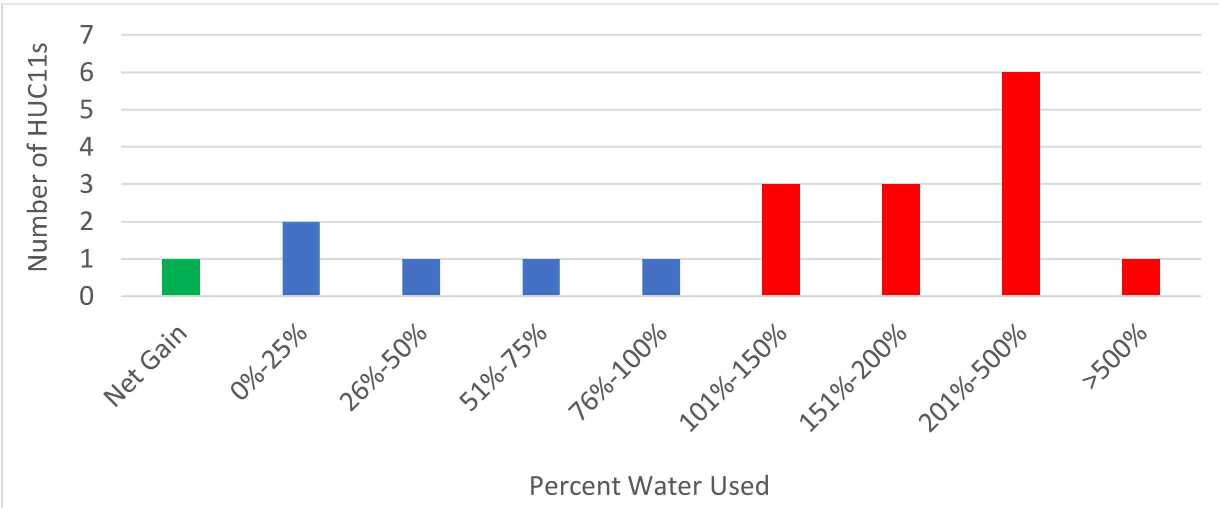


Figure J10a. WMA17 HUC11 Count by Percentage of Total Availability Used (Rolling Average Three-Year Peak in Depletive and Consumptive Loss 2011-2020)

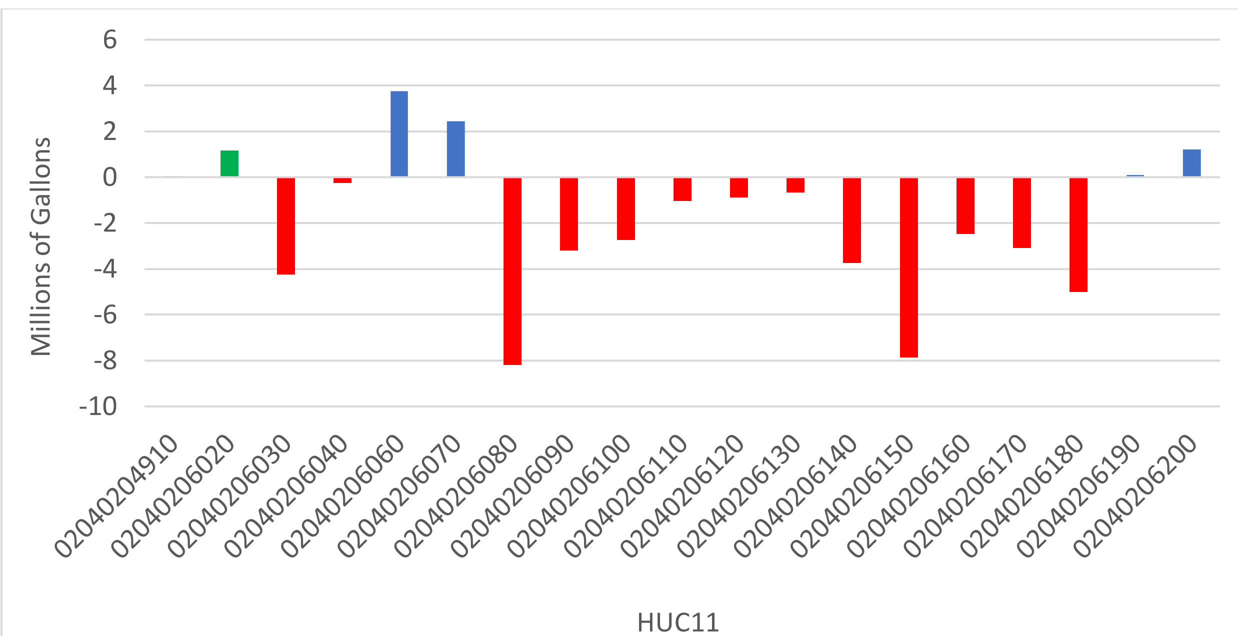


Figure J10b. WMA17 HUC11 Remaining Available Water for Rolling Average Three-Year Peak in Depletive and Consumptive Loss (2011-2020)

7.2 WATER QUALITY

Water quality degradation of WMA17 surface water sources has occurred, which poses a threat to both regional surface water and groundwater sources. The regional water system is highly interconnected, in which the water quality of the surface water system is connected with the unconfined groundwater system (NJ Division of Fish and Wildlife, 2004). Sources of surface water contamination can include: (a) deforestation/development; (b) urbanization; (c) agricultural operations; (d) municipal and industrial wastewater discharge (point source); (e) artificial channelization; (f) upstream impoundments; (g) drought conditions; and (h) leaking septic systems (Sickels & Associates, Inc., 2021; NJ Division of Fish and Wildlife, 2004; Rutgers Cooperative Extension Water Resources Program, 2012; Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006). Information about the water quality of WMA17's three major rivers are provided below.

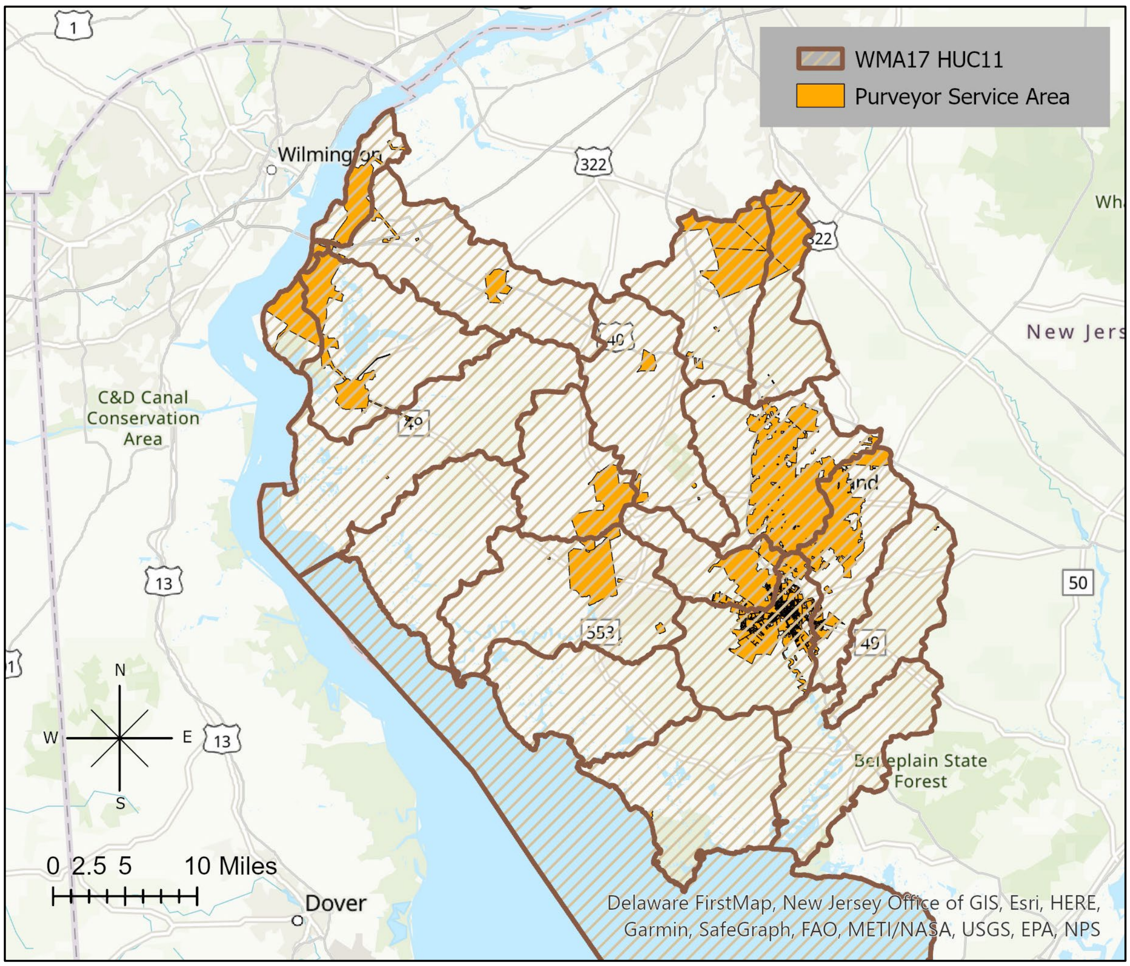
- **Salem River**: According to NJDEP's 2018/2020 New Jersey Integrated Water Quality Assessment Report, the Salem River is failing to meet water quality standards in Dissolved Oxygen (DO), pH, Total Phosphorus, Total Suspended Solids, turbidity, Arsenic, and *E. coli*. Salem River tributaries have also been found to suffer from impairment. For example, Majors Run has been found to suffer from excessive fecal coliform levels (NJDEP Division of Water Monitoring and Standards, 2021a; NJDEP Division of Water Monitoring and Standards, 2021b).
- **Maurice River**: The Maurice River has been found to be severely impaired with high concentrations of Mercury, coliform bacteria, Arsenic, and Lead. Parts of the Maurice River also have excessive levels of *E. coli* and Arsenic (NJDEP Division of Water Monitoring and Standards, 2021a; NJDEP Division of Water Monitoring and Standards, 2021b).
- **Cohansey River**: The Cohansey River (particularly its headwaters) is considered highly vulnerable to contamination, and a Watershed Restoration Plan has been adopted to reduce its fecal coliform, Lead, and Phosphorus concentrations (Salem County Agriculture Development Board & Salem County Open Space Advisory Committee, 2008; Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006). Water quality testing of the Cohansey River for the NJDEP's 2018/2020 New Jersey Integrated Water Quality Assessment Report shows that the Cohansey River suffers from elevated levels of Total Phosphorus and fecal coliform (NJDEP Division of Water Monitoring and Standards, 2021a).

Groundwater sources in WMA17 also face water quality risks, especially in its recharge areas. Since the Kirkwood-Cohansey Aquifer is recharged from percolation by precipitation, risks to the aquifer include contamination from agricultural chemicals, illegal dumping, chemical spills, and septic systems. However, one benefit for the Kirkwood-Cohansey Aquifer is that, unlike the PRM Aquifer, which has heavily developed recharge areas, most of its recharge area is not developed. Since the PRM Aquifer has an overlying clay layer to protect it, it is considered less vulnerable to contamination than the MLW Aquifer (Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006; NJ Division of Fish and Wildlife, 2004). However, water withdrawals and sea level rise both increase concerns of saltwater intrusion into WMA17's aquifers.

8. WATER UTILITIES AND WATER INFRASTRUCTURE

KEY FINDINGS

- Although most of WMA17's PCWSs reported a decline in potable water demand between 2011-2020, the largest increases in potable supply demand were Pennsville Township WD, New Jersey American Water – Logan, and Clayton Borough WD.
- WMA17 PCWS 2050 demands projections indicate that roughly half of WMA17 PCWSs will have decreased demand, but several PCWSs, such as Bridgeton City WD and Washington Township MUA, are anticipated to experience demand increases in 2050.
- WMA17 PCWS 2050 demands projections also suggest that some PCWSs servicing WMA17 Gloucester municipalities may face difficulties in meeting 2050 demand, with demands exceeding current PCWS capacity. While almost all Salem County PCWSs are projected to experience demand decline in 2050, PCWSs servicing Cumberland County municipalities are projected to have a mix of demand increase and decline.



Map J9: Public Community Water System (PCWS) Purveyor Service Areas in WMA17's HUC11s
Source: NJDEP Bureau of GIS

Table J7 shows the public community water systems (PCWSs) that serve over 1,000 people and service the HUC11s in WMA17 (See Map J9 for all PCWS purveyor service areas in WMA17's HUC11s). The listed PCWSs that serve Salem County include New Jersey American Water-Penns Grove, Pennsville Township WD, Woodstown WD, and Salem WD. Cumberland County's PCWSs include Upper Deerfield Township

WD, Bridgeton City WD, Millville WD, and Vineland Water & Sewer Utility. Gloucester County is serviced by several PCWSs including Washington Township MUA, Glassboro Borough WD, Clayton Borough WD, Logan Township MUA, Monroe Township MUA, and New Jersey American Water - Logan. While most of the listed PCWSs reported a decline in potable water demand, Pennsville Township WD, New Jersey American Water – Logan, and Clayton Borough WD reported the largest increase in potable supply demand between 2011 and 2020 (NJDEP Division of Water Supply and Geoscience, 2022a; NJGWS, 2022). Of the PCWSs, Clayton Borough WD reported a firm capacity deficit (approximately -0.1 mgd); firm capacity represents the ability of a utility to provide water with its largest unit out of production (e.g., the largest well in a wellfield) (NJDEP Division of Water Supply and Geoscience, 2022b).

Table J8 provides NJDEP 2050 projected demands for WMA17's major PCWSs based on the demand projections provided in Appendix D. The table provides four 2050 projected demands scenarios, which include nominal and optimal water loss scenarios under a No Conservation and Conservation scenario. Nominal water loss scenarios assume that 2050 water losses will be the same as current median PCWS water losses for the Coastal Plain region. Optimal water loss scenarios assume that PCWSs will meet a more aggressive water loss standard (25^{th} percentile for the Coastal Plain region). No Conservation scenarios assume that recent per capita demands remain stable through 2050, while Conservation scenarios assume a 10% reduction in per capita demands. Surplus/Deficit refers to limitations of an Allocation Permit or Water Use Registration minus the sum of demand recorded based on water use records plus demand projected for approved projects. Often, this data is expressed as either annual (mgy) or monthly (mgm) data, but it is expressed as average daily volumes (mgd) in Table J8. Negative surplus/deficit values indicate a shortage in diversion privileges or available supplies through bulk transfer agreements (NJDEP Division of Water Supply and Geoscience, 2022b).

Overall, roughly half of WMA17's PCWSs are projected to have demand decline (indicating more available firm capacity), and only one PCWS (Fairview Manor Mobile Home Park) is anticipated to experience deficit by 2050. WMA17 PCWSs projected to experience demand increases include Bridgeton City WD, Washington Township MUA, and Monroe Township MUA. Potential concern was identified for Monroe Township MUA, since deficit was detected in one of its 2050 peak demands scenarios (not listed in Table J8). Demand decline was projected for many PCWSs servicing Salem municipalities, including Salem WD, New Jersey American – Penns Grove, Woodstown Borough WD, and Elmer Borough WD. These findings align with the findings from Section 4's population projections section, which projects Salem County's population to decline through 2050.

Purveyor	Purveyor ID	HUC11s Served	Demand Percent Change (2011-2020)	Average Demand (mgy) (2011-2020)	Max Demand (mgy) (2011-2020)
NJ American Water- Penns Grove	NJ1707001	02040206020, 02040206030	-15%	407	504
Pennsville Township WD	NJ1708001	02040206020, 02040206030, 02040206040	28%	357	427
Woodstown WD	NJ1715001	02040206030	-11%	128	137
Salem WD	NJ1712001	02040206040, 02040206060	-9%	324	361
NJ American Water- Logan	NJ0809002	02040206020	13%	404	439
Upper Deerfield Township WD	NJ0613004	02040206080, 02040206090, 02040206150, 02040206160	-38%	156	207
Bridgeton City WD	NJ0601001	02040206090	-7%	1,094	1,200
Fairton Federal Correctional Institution	NJ0605004	02040206090	1%	68	75
Monroe Township MUA	NJ0811002	02040206120, 02040206130	-0.3%	893	945
Glassboro Borough WD	NJ0806001	02040206120	-26%	638	711
Clayton Borough WD	NJ0801001	02040206120, 02040206130	8%	201	234
Harding Woods MPH	NJ1710001	02040206120	-5%	25	29
Washington Township MUA	NJ0818004	02040206120, 02040206130	-12%	1,447	1,714
Vineland Water & Sewer Utility	NJ0614003	02040206130, 02040206140, 02040206160, 02040206170, 02040206180	-22%	2,662	3,054
Buena Borough MUA	NJ0104003	02040206140, 02040206180	-10%	182	198
Newfield WD	NJ0813001	02040206140	-30%	55	78
Millville WD	NJ0610001	02040206140, 02040206160, 02040206170, 02040206180, 02040206200	-10%	1,176	1,291
Elmer Borough WD	NJ1702001	02040206150	-18%	45	51
United Mobile Homes of Vineland	NJ0614005	02040206180	0.4%	31	41

Table J7. Public Community Water Systems in WMA17 Servicing More Than 1,000 People and the HUC11(s) They Serve
Data provided by NJDEP DWSG (NJDEP Division of Water Supply and Geoscience, 2022a; NJGWS, 2022)

				2050 No Conservation Scenario		2050 Conservation Scenario	
Purveyor ID	Purveyor	Average Daily Demand (2020) (mgd)	2020 Deficit/ Surplus (mgd)	Nominal Water Loss Scenario (mgd)	Optimal Water Loss Scenario (mgd)	Nominal Water Loss Scenario (mgd)	Optimal Water Loss Scenario (mgd)
NJ1707001	NJ American - Penns Grove	1.1	2.2	0.9	0.8	0.8	0.8
NJ1708001	Pennsville Township WD	1.1	1.6	0.9	0.8	0.8	0.7
NJ1715001	Woodstown Borough WD	0.3	0.5	0.3	0.3	0.2	0.2
NJ1712001	Salem WD	0.8	1.0	0.7	0.7	0.6	0.6
NJ0809002	NJ American - Logan	1.2	1.8	1.1	1.0	1.0	0.9
NJ0613004	Upper Deerfield Township WD	0.4	1.1	0.4	0.4	0.4	0.4
NJ0601001	Bridgeton City WD	2.9	4.1	3.5	3.3	3.1	3.0
NJ0605004	Fairton Federal Correctional Institution	0.2	0.4	NA	NA	NA	NA
NJ0811002	Monroe Township MUA	2.4	4.0	2.9	2.8	2.7	2.5
NJ0806001	Glassboro Borough WD	1.7	3.6	1.6	1.6	1.5	1.4
NJ0801001	Clayton Borough WD	0.6	0.9	0.6	0.6	0.6	0.6
NJ1710001	Harding Woods MPH	0.1	0.1	0.1	0.1	0.1	0.1
NJ0818004	Washington Township MUA	3.8	6.0	4.3	4.1	3.8	3.7
NJ0614003	Vineland Water & Sewer Utility	6.8	10.0	7.2	6.9	6.5	6.2
NJ0104003	Buena Borough MUA	0.5	0.7	0.5	0.5	0.5	0.4
NJ0813001	Newfield Borough WD	0.1	0.5	0.1	0.1	0.1	0.1
NJ0610001	Millville WD	3.1	5.0	3.1	3.0	2.8	2.7
NJ1702001	Elmer Borough WD	0.1	0.2	0.1	0.1	0.1	0.1
NJ0614005	**Fairview Manor Mobile Home Park**	0.1	0.1	0.2	0.2	0.1	0.1

Table J8. WMA17 2050 PCWS Demands Projections (NJDEP projections based on Van Abs et al., 2018)
*Red bold text indicates PCWSs in deficit in non-peak 2050 scenarios

Within the WMA17 region, areas already possessing sewer infrastructure are established areas and areas prioritized for future growth (Heyer, Gruel & Associates and Michael Baker International, 2018a). Typically, WMA17 locations with public water service also have approved sewer service (DVRPC, 2009; Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015). Information on WMA17 county sewer infrastructure is included below.

- **Salem County**: Seven wastewater treatment facilities serve Salem County, and in 2016, they provided 11 Salem municipalities with wastewater services. To meet future wastewater management demands, the following Salem municipalities were projected to require new or expanded capacity to meet demand: (a) Carney's Point Township; (b) Oldmans Township; (c) Elmer Borough; and (d) Pittsgrove Township (Sickels & Associates, Inc., 2016).
- **Cumberland County**: has six facilities that provide sewer service. The largest of these providers are Landis Sewerage Authority, Millville Sewer Utility, and Cumberland County Utilities Authority (DVRPC, 2009). Areas within Cumberland County that have sewer service are the north central portion of the county in Vineland, Bridgeton, and Millville.
- **Gloucester County**: has two distinct sewer service areas of the Gloucester County Utility Authority (GCUA): (a) Consolidated District, and (b) Non-consolidated District. Serving about 80% of the county's population as of 2013, the GCUA Consolidate District service areas include all or parts of 16 Gloucester County municipalities. The GCUA Non-consolidated District includes most of Gloucester County's farmlands and includes all or part of 15 municipalities; most of this area does not have installed sewer collection systems, which are confined to developed areas (Land Conservancy of NJ & Gloucester County Agriculture Development Board, 2015).

8.1 RELATIONSHIP BETWEEN PROJECTED WATER USE AND DEMOGRAPHIC CHANGES

While some findings from the 2050 PCWS water demands projections align with findings from the population projections discussed in Section 4, the 2050 demands projections provide evidence that regional PCWSs will overall be able to meet future demand. One potential concern identified in Section 4 was that Gloucester County was projected to experience significant population growth through 2050. Several PCWSs projected to have future demand increase, such as Washington Township MUA and Monroe Township MUA, service some of Gloucester's WMA17 municipalities. These PCWSs were projected to have a remaining capacity of approximately 21% and -4% (indicates deficit) in their peak demand across all 2050 scenarios (including peak scenarios), respectively. One PCWS (Clayton Borough WD) servicing Gloucester's Clayton Borough had split projections. Split projections indicate a PCWS had projected demand increase and decline among its 2050 Non-conservation and Conservation scenarios, respectively. However, as there are several PCWSs servicing Gloucester County municipalities that are projected to have demand decline (New Jersey American-Logan, Glassboro Borough WD, Newfield Borough WD), it is likely that even if potential deficits arise in the future, alternative supplies could be available to meet future demand through interconnections. In addition, potential strategies for PCWSs to improve their surplus/deficit include installation of new infrastructure, engaging in bulk transfer agreements with other PCWSs, emphasizing demand reductions during peak periods (e.g., summer months), making regulatory adjustments to change demand patterns, and identification of new water sources.

Many of the PCWSs projected to experience demand decline service Salem municipalities, while PCWSs servicing Cumberland municipalities had a mix of projected demand increase and decline. This aligns with the expected population decline projected for Salem County and small population growth projected for Cumberland County through 2050. PCWSs with projected demand decline that service

Salem municipalities include Salem WD, New Jersey American – Penns Grove, Pennsville Township WD, Woodstown Borough WD, and Elmer Borough WD. These PCWSs (with the exception of Pennsville Township WD and Elmer Borough WD) service the focus municipalities, Carney's Point Township, Pilesgrove Township, and Salem City. Among the PCWSs servicing Cumberland County municipalities, projections included demand decline for several PCWSs, including Newfield Borough WD and Millville WD, and demand increase for Bridgeton City WD. Several PCWSs servicing Cumberland municipalities, such as Upper Deerfield Township WD and Vineland Water & Sewer Utility were split between projecting demand increase and decline among their 2050 Non-conservation and Conservation scenarios, respectively. While there is some uncertainty about future demand among PCWSs servicing Cumberland County municipalities, the overall findings for PCWSs servicing Salem and Cumberland counties suggest that the water supply provided by these PCWSs should be adequate to meet future water demand in 2050.

9. CLIMATE CHANGE AND SEA LEVEL RISE ASSESSMENT

KEY FINDINGS

- Among the WMA17 counties, Atlantic County is projected to have the largest increase in precipitation across different storm events between 2020-2069.
- Projections of WMA17 water withdrawal and wastewater discharge site inundation for 2050 and 2100 suggest HUC11s 02040206040 and 02040206030 will experience the most facility inundation, followed by 02040206100 and 02040206020. The majority of withdrawal permit sites projected to be inundated with two and five feet of sea level rise are used for agricultural purposes.
- WMA17 communities located along the Delaware River/Bay and WMA17's three main rivers (Salem, Maurice, and Cohansey) are projected to be most vulnerable to inundation from sea level rise. While Salem Water Department is projected to experience the most inundation of its service area among major PCWSs servicing WMA17, the focus municipalities, Bridgeton City, Millville City, and Salem City are projected to have the largest number of Overburdened Community census blocks vulnerable to inundation from sea level rise.

9.1 GENERAL CLIMATE CHANGE PROJECTIONS FOR THE WMA17 REGION

Climate forecasts in WMA17 are anticipated to follow state-wide trends for temperature and sea level rise. Temperature, sea level rise, and precipitation projections for 2050 are included below.

- **Temperature**: Statewide temperatures are projected to increase between 4.1 to 5.7 degrees Fahrenheit by 2050. Winters are anticipated to warm faster (compared to the other seasons), and summers are expected to become hotter.
- **Sea Level Rise**: Statewide sea levels are projected to rise between 1.4 and 2.1 feet by 2050. "Sunny day flooding" is anticipated to occur more frequently, and hurricanes, Nor'easters, and other extreme weather events are projected to increase in severity and frequency.
- **Precipitation**: Overall, New Jersey is projected to receive 4 to 11% more precipitation by 2050. Larger rainfall events are anticipated to increase in frequency, and fall and spring seasons are projected to become wetter (NJDEP, 2020).

	2-Year Storm	5-Year Storm	10-Year Storm	25-Year Storm	50-Year Storm	100-Year Storm
Atlantic	18%	17%	19%	23%	26%	30%
Cumberland	16%	16%	16%	19%	23%	28%
Gloucester	16%	16%	17%	19%	22%	26%
Salem	17%	18%	19%	21%	22%	24%

Table J9. Projected Percent Increase for Precipitation among WMA17 Counties (Moderate RCP 4.5 Scenario for 2020-2069)

Table J9 shows the precipitation projections for WMA17 counties for different level storm events provided by the New Jersey Extreme Precipitation Projection Tool. These numbers reflect the upper likelihood for projected precipitation increases, representing a 17% chance that precipitation will increase more than the value shown. As shown in the table, Atlantic County is projected to have the largest precipitation increase among WMA17 counties. Among the three remaining counties, Salem County is projected to have a greater precipitation increase during smaller rain events compared to Cumberland and Gloucester counties, while Cumberland and Gloucester are anticipated to have more

precipitation increase during larger rain events compared to Salem (NJDEP, Northeast Regional Climate Center, & Cornell University, 2023).

9.2 POTENTIAL CHANGES TO WMA17 WATER AVAILABILITY DUE TO CLIMATE CHANGE

INUNDATION OF WMA17 AQUIFERS

Inundation of unconfined aquifer systems in the WMA17 region is one critical concern resulting from sea level rise. Research conducted by NJDEP's DWSG finds a two foot increase in sea level would most significantly impact the Kirkwood-Cohansey Aquifer system, with approximately 31,500 acres of the aquifer being directly inundated by sea water. However, with two and five feet of sea level rise, approximately 83,000 and 98,000 acres of the Kirkwood-Cohansey's outcrop (recharge) area would be inundated, respectively. The two and five feet standards are used by in this Plan to approximate a high-end measure of likely sea level rise for 2050 and 2100, respectively (less than a 17% chance of sea level rise exceeding the height indicated).

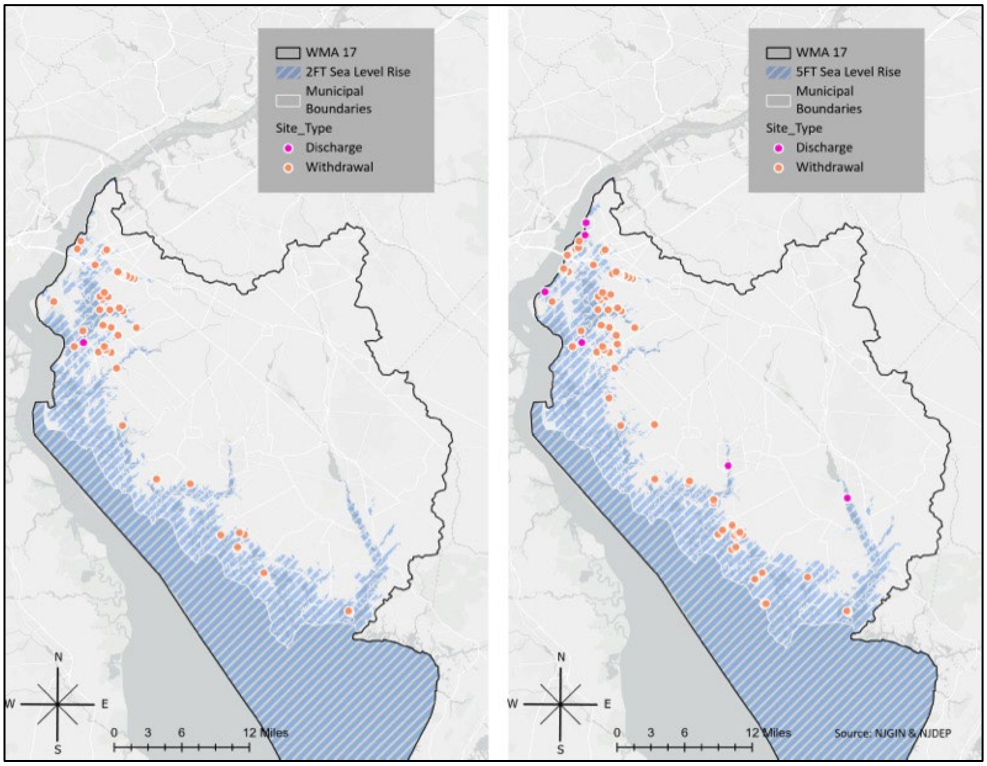
Inundation of confined aquifer outcrop (or recharge) areas also provides a risk for WMA17 fresh water sources to be infiltrated with sea water. Two confined aquifers at risk in WMA17 include the Magothy (Upper PRM Aquifer) and Potomac (Lower PRM Aquifer) formations. DWSG projects that approximately 8,100 acres of the Magothy Formation and 5,200 acres of the Potomac Formation's outcrop areas will be inundated with two feet of sea level rise.

WMA17 SITE INUNDATION FROM SEA LEVEL RISE

Sea level rise also poses the risk of WMA17 water withdrawal and wastewater discharge sites becoming inundated with salt water. According to DWSG, unconfined wells with direct connections to the surface would immediately experience inundation from two feet of sea level rise. Confined wells can also face the risk of direct inundation of sea water from the actual wellhead (vertical migration).

The DWSG database, New Jersey Water, identifies withdrawal and return sites (such as intake pipes, withdrawal wells, discharge sites, and surface water withdrawal sites) used for potable supply, agricultural, industrial, and commercial purposes that are projected to be inundated with two and five feet of sea level rise (see Map J10). However, the New Jersey Water sites provided here may not match with those provided in the NJDEP permit/regulatory database.

As shown in Map J10, all WMA17 permitted sites projected to be inundated in these scenarios are located in Salem and Cumberland counties. With two feet of sea level rise, Salem has many more withdrawal sites that are inundated compared to Cumberland County (37 compared to 9). However, more Cumberland County sites become inundated with five feet of sea level rise than in Salem (Cumberland's inundated permit sites increase to 26 while Salem's increase to 49).



Map J10. WMA17 Withdrawal and Discharge Sites Projected to be Inundated with 2ft and 5ft of Sea Level Rise

HUC11	Number of Sites Inundated (2ft)	Number of Sites Inundated (5ft)
	Withdrawal Sites	
02040206020	3	7
02040206030	14	17
02040206040	18	22
02040206060	1	2
02040206070	1	2
02040206090	2	4
02040206100	4	14
02040206110	1	5
02040206200	2	2
	Discharge Sites	
02040206020	0	4
02040206040	1	1
02040206090	0	1
02040206170	0	1

Table J10. WMA17 Withdrawal and Discharge Sites Inundated by HUC11 (2ft and 5ft of Sea Level Rise)

Table J10 shows the number of WMA17 withdrawal and discharge sites that are projected to be inundated with two and five feet of sea level rise. Based on New Jersey Water database data, the WMA17 HUC11s anticipated to experience the most inundation are 02040206040 and 02040206030, with both HUC11s projected to experience significant site inundation with two feet of sea level rise. 02040206100 is also anticipated to have a significant increase in sites inundated with five feet of sea level rise. HUC11s, 02040206020 and 02040206110, are anticipated to experience minimal site inundation with two feet of sea level rise, but have increases in inundation of permitted sites with five feet of sea level rise.

Figure J11 shows which WMA17 municipalities are projected to experience the most withdrawal site inundation with two and five feet of sea level rise. As shown in the figure, Mannington Township is expected to experience the largest number of sites inundated, followed by the focus municipality, Carney's Point Township, and Lawrence Township. PCWSs in Salem City and Pennsville Township have withdrawal sites projected to be inundated with two and five feet of sea level rise, respectively. Another focus municipality, Pilesgrove Township, is projected to have minimal withdrawal site inundation with sea level rise.

Several focus municipalities are also projected to have discharge site inundation with two and five feet of sea level rise. Discharge sites for sewer treatment facilities in Carney's Point Township, Millville City, and Bridgeton City are projected to be inundated with five feet of sea level rise, with facilities in Salem City becoming inundated with two feet of sea level rise, complicating the discharge process by backing treated wastewater up the pipelines. Inundation of WMA17's PCWS purveyor service areas with two and five feet of sea level rise will be discussed in the next sub-section.

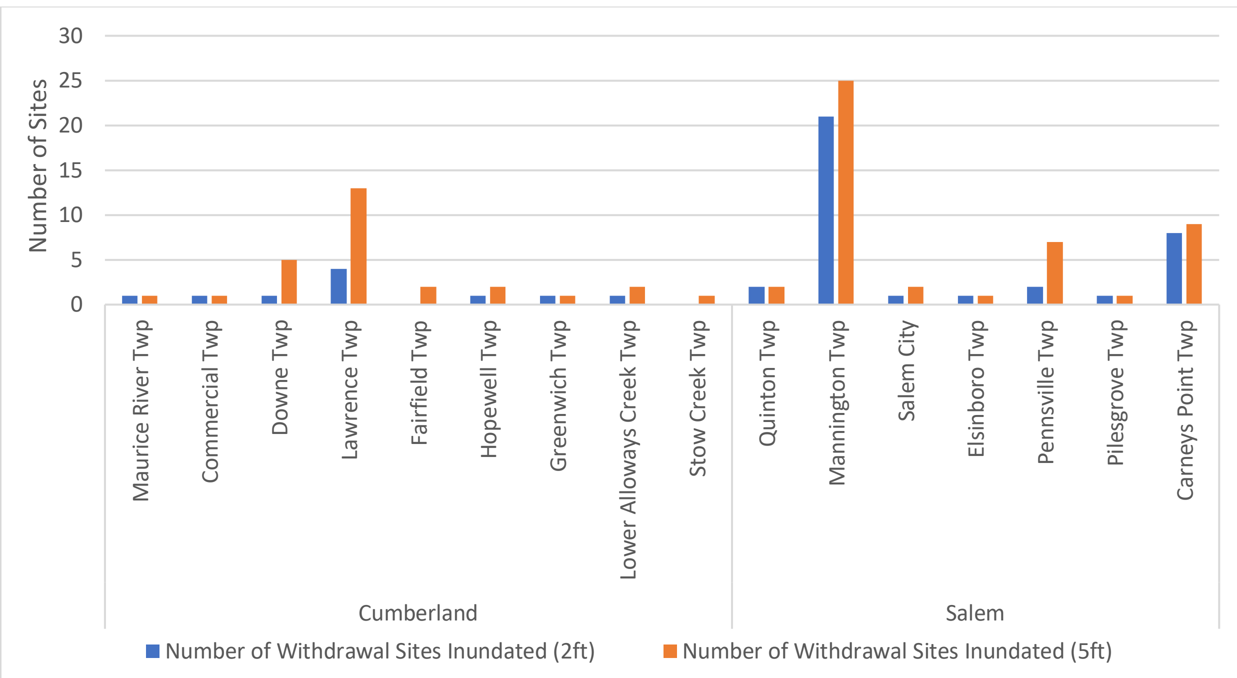


Figure J11. The Number of Withdrawal Sites in WMA17 Inundated with 2ft and 5ft of Sea Level Rise

Figure J12a and b show the water use group information of the withdrawal sites that are projected to be inundated with two and five feet of sea level rise. As shown in the pie charts, withdrawal sites projected to be most significantly inundated with two and five feet of sea level rise are sites dedicated to agricultural use. Approximately 83% and 75% of projected inundated withdrawal sites are dedicated to

agricultural use in the two and five feet sea level rise scenarios, respectively. Withdrawal sites for commercial/industrial purposes was the next largest use group to be inundated with two and five feet of sea level rise, although the number of inundated sites for this use group decreased as a percentage of total inundated sites in the five feet scenario (compare 15% to 13%). While inundation of withdrawal sites dedicated to potable supply are projected to be minimal with two feet of sea level rise, the number of sites inundated increases from one to nine with five feet of sea level rise.

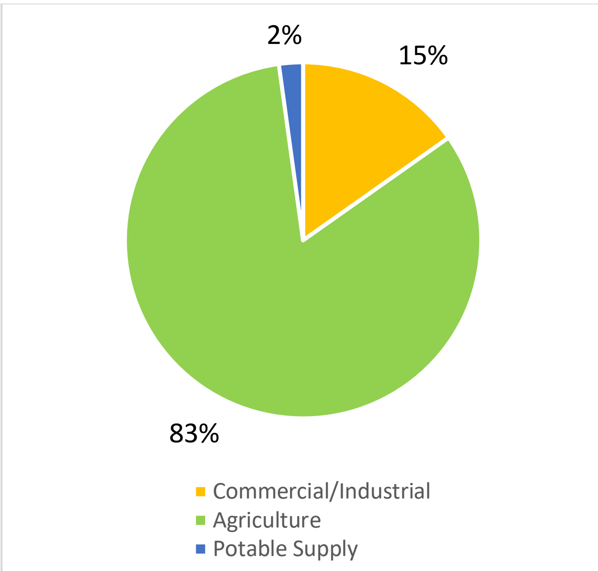


Figure J12a. WMA17 Withdrawal Site Inundation by Use Group (2ft of Sea Level Rise)

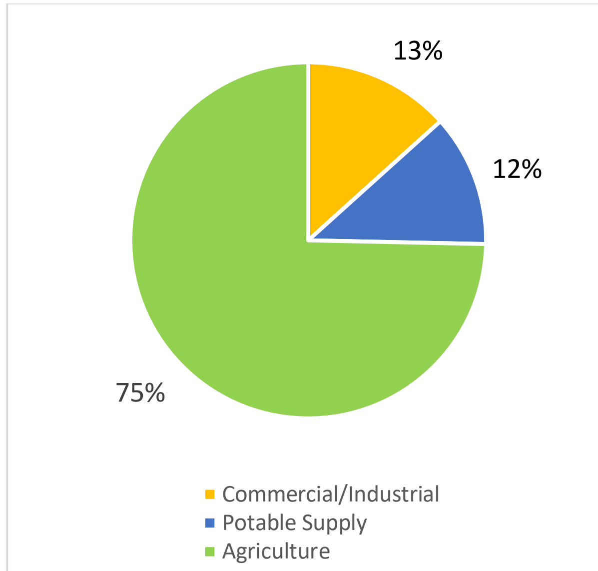


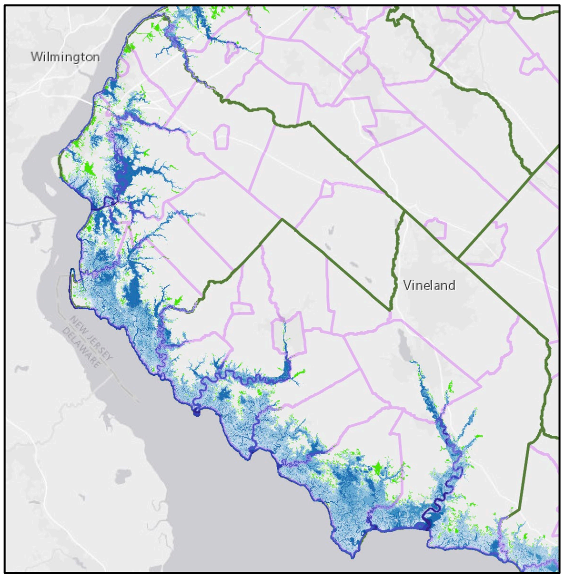
Figure J12b. WMA17 Withdrawal Site Inundation by Use Group (5ft of Sea Level Rise)

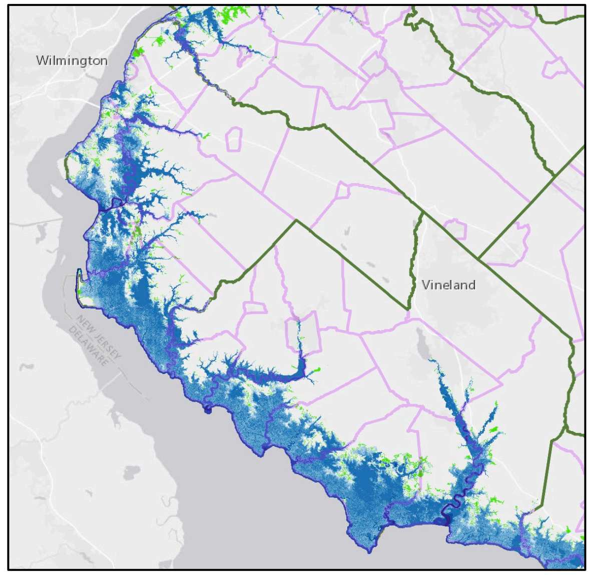
9.3 WMA17 COMMUNITY VULNERABILITY TO SEA LEVEL RISE

Since WMA17 is partially coastal in nature, sea level rise is anticipated to remove a significant portion of Cumberland County's low-lying land area located along Delaware Bay. The anticipated loss of tidal wetlands to open water is expected to create a threat to both the sustainability and resilience of the Delaware Bayshore (SJEDD, 2021; Simone Collins Landscape Architecture & Reed Group, 2011). However, WMA17 municipalities along the Delaware Bay and its tributaries are anticipated to experience additional risk from flooding, coastal erosion, and storm surge (Cumberland County OEM & Stuart Wallace LLC, 2022; Tetra Tech, 2022).

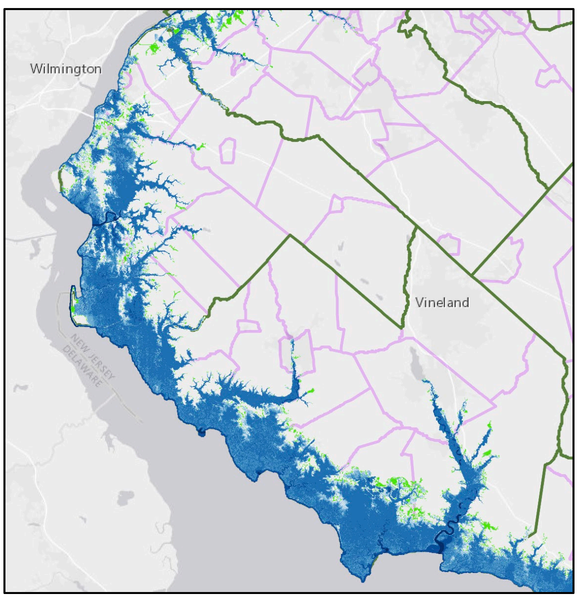
Map J11a and b show different scenarios for projected sea level rise within the WMA17 region provided by NJFloodMapper (Rutgers Center for Remote Sensing and Spatial Analysis, 2017). FloodMapper measures both sea level rise and the metric, Total Water Level (a comprehensive measure that considers sea level rise (permanent inundation), high tide flooding, and extreme coastal flooding). The maps on the left in both figures show projected permanent inundation of the WMA17 area, reflecting two feet of sea level rise for 2050 and five feet of sea level rise for 2100. The maps on the right show flood event water levels for the WMA17 region with two and five feet of sea level rise and a two-year flooding event, respectively. Two-year flooding event is defined as a precipitation event having a 50% NOAA Annual Exceedance Probability (likelihood of exceeding a certain amount of precipitation at least once in any given year); inundation would be higher with larger coastal storm surge. As shown in the maps in blue and green, the most significant inundation is anticipated in municipalities located along the Delaware River/Bay and along WMA17's three main rivers (Salem, Maurice, and Cohansey), where saltwater can more readily move inland. Community vulnerability to sea level rise is greater than

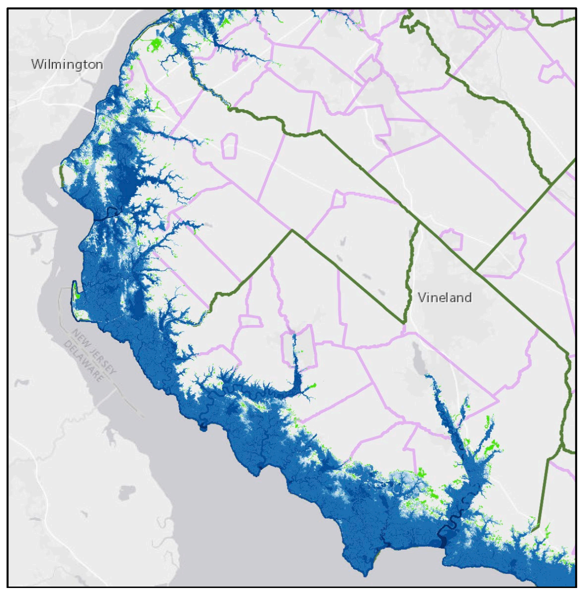
projected in the maps on the left as more widespread and severe inundation is anticipated with storm flooding events (reflected in the maps on the right).





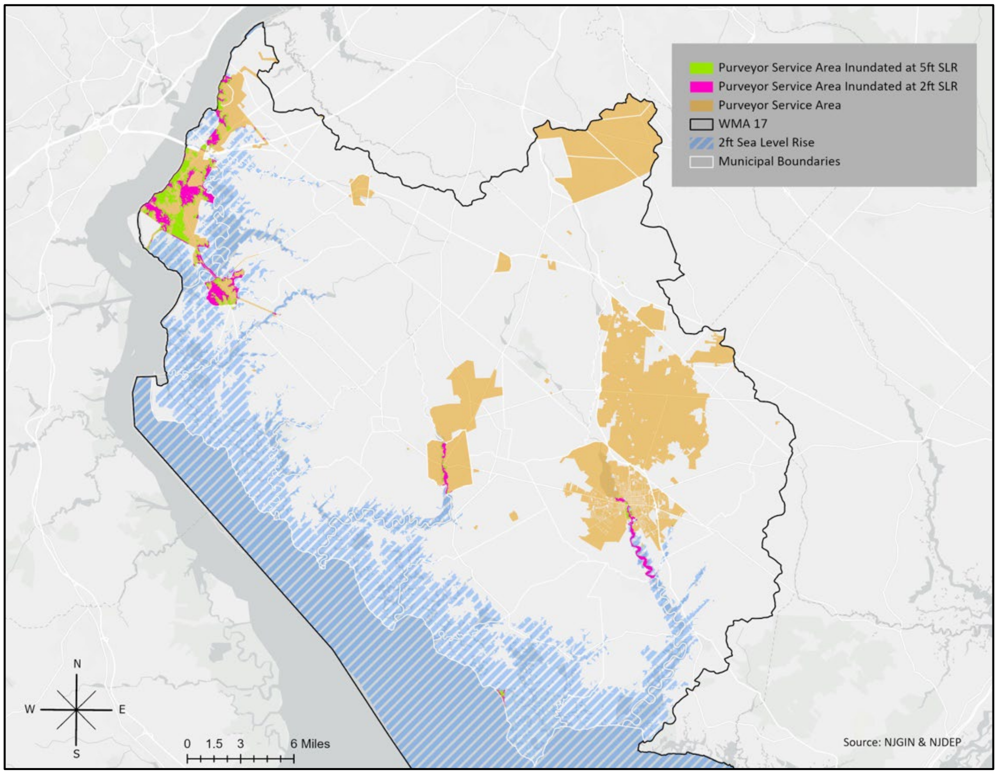
Map J11a. (Left) Map of the WMA17 region with 2ft of Sea Level Rise (2ft TWL); (Right) Map of the WMA17 Region with 2ft of Sea Level Rise and a 2-Year Flooding Event (4ft TWL)





Map J11b. (Left) Map of the WMA17 region with 5ft of Sea Level Rise (5ft TWL); (Right) Map of the WMA17 Region with 5ft of Sea Level Rise and a 2-Year Flooding Event (7ft TWL)

Inundation of WMA17's PCWS purveyor service areas from sea level rise is one community threat to regional water availability. Map J12 shows the major WMA17 PCWS purveyor service areas projected to be inundated with two and five feet of sea level rise. The major PCWSs projected to have inundation of their service areas include Upper Deerfield Township WD, New Jersey American – Penns Grove, Pennsville Township WD, and several PCWSs located in focus municipalities (Bridgeton City WD, Millville WD, and Salem WD).



Map J12. Projected Inundation of Major WMA17 PCWS Service Areas with 2ft and 5ft of Sea Level Rise

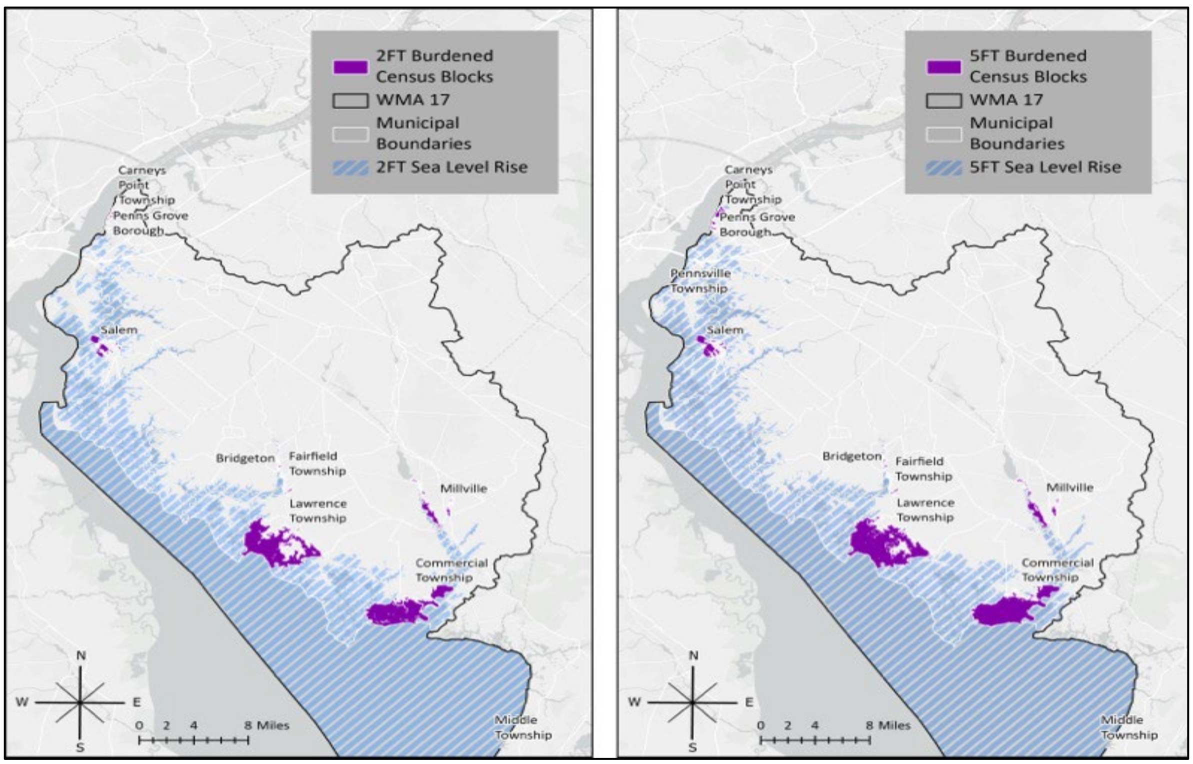
Table J11 provides the projected percent inundation of major WMA17 PCWS service areas with two and five feet of sea level rise. As shown in the table, the major WMA17 PCWS projected to have the most inundation of its service area is Salem WD, with over 40% and 60% of its service area projected to be inundated with two and five feet of sea level rise, respectively. Salem WD services HUC11s containing several focus municipalities including Carney's Point Township, Pilesgrove Township, and Salem City. Pennsville Township WD is also projected to have inundation of its service area, with projections of almost a quarter of its service area being inundated with two feet of sea level rise. Pennsville Township WD also services HUC11s containing several focus municipalities (Carney's Point Township, Pilesgrove Township, and Salem City) and Gloucester County's Logan Township. Bridgeton City WD and Millville WD are both projected to have minimal inundation of their service areas. However, these PCWSs service HUC11s containing Millville City, Bridgeton City, Vineland City, along with several Gloucester County municipalities (Franklin Township and Newfield Borough).

Purveyor ID	Purveyor	Percent Inundated (2ft of Sea Level Rise)	Percent Inundated (5ft of Sea Level Rise)
NJ0610001	Millville WD	5%	6%
NJ1707001	NJ American - Penns Grove	14%	25%
NJ1708001	Pennsville Township WD	24%	57%
NJ1712001	Salem WD	42%	62%
NJ0601001	Bridgeton City WD	6%	9%

Table J11. Major WMA17 PCWS Purveyor Service Areas Projected to be Inundated with 2ft and 5ft of Sea Level Rise
Data provided by NJDEP DWSG

Map J13 shows the NJDEP's Overburdened Community census blocks in WMA17 that are projected to be inundated with two and five feet of sea level rise. All of the WMA17 Overburdened Community census blocks projected to be inundated with two and five feet of sea level rise are located in Salem and Cumberland counties. Areas projected to have the most census block inundation with both two and five feet of sea level rise include Penns Grove Borough, and the focus municipalities, Bridgeton City, Millville City, and Salem City. Almost all of the census block groups (11 of 14 for two feet of sea level rise; 16 of 19 for five feet of sea level rise) projected to be inundated from these municipalities meet both the low income and minority criteria of the Overburdened Community definition.

Table J12 provides the Overburdened Community census block groups in WMA17's focus municipalities projected to be inundated with two and five feet of sea level rise. As shown in the table, the focus municipality containing the most Overburdened Community census blocks at-risk from sea level rise is Bridgeton City, followed by Millville City and Salem City. As the majority of the at-risk census blocks are projected to be inundated at two feet of sea level rise, early action to protect these communities and their vulnerable populations is critical as the majority of sea level rise impacts to these communities are projected to occur sooner (by 2050) rather than later (by 2100).



Map J13. WMA17 Overburdened Community Census Block Groups Inundated with 2ft and 5ft of Sea Level Rise

Focus Municipality	Number of Census Block Groups Inundated (2ft of Sea Level Rise)	Census Block Groups Inundated (2ft of Sea Level Rise)	Number of Census Block Groups Inundated (5ft of Sea Level Rise)	Census Block Groups Inundated (5ft of Sea Level Rise)
Carney's Point Township	1	340330204002	1	340330204002
Salem City	3	340330219001, 340330220001, 340330221001	3	340330219001, 340330220001, 340330221001
Bridgeton City	5	340110201001, 340110206003, 340110202001, 340110203001, 340110205031	7	340110201001, 340110202001, 340110202002, 340110203001, 340110205031, 340110205032, 340110206003
Millville City	3	340110302002, 340110303002, 340110305021	4	340110301001, 340110302002, 340110303002, 340110305021

Table J12. Overburdened Community Census Block Groups in WMA17's Focus Municipalities Projected to be Inundated with 2ft and 5ft of Sea Level Rise

10. POTENTIAL MANAGEMENT OPTIONS

Based on the findings from the analysis, WMA17 currently faces water supply vulnerability, which is heightened during periods of drought and has the risk of becoming more severe in the future with climate change, sea level rise, and population change. Included below are some of WMA17's locations found to be the most vulnerable, along with some of the major highlights from the assessment's findings for these areas.

- **02040206030 (Salem R (above 39d40m14s dam)/Salem Canal)**: includes two focus municipalities (Carney's Point Township and Pilesgrove Township) and includes areas Salem County planners identified as most promising for growth. This HUC11 had the second highest five-year average water withdrawal by water use category and fourth most negative remaining available water value for its three-year rolling average in peak depletive/consumptive loss in WMA17. One of its PCWSs, Pennsville Township WD, reported the largest demand increase between 2011-2020 among larger WMA17 PCWSs (28%). This HUC11 was found to have the second largest number of projected withdrawal sites inundated with two and five feet of sea level rise, with significant site inundation in both Mannington Township and Carney's Point Township.
- **02040206080 (Cohansey River (above Sunset Lake))**: includes both Upper Deerfield Township and Hopewell Township, which were identified by Cumberland County planners as areas that had potential to experience future growth. Out of the WMA17 HUC11s, 02040206080 had the fourth highest five-year average water withdrawals by water use category, and was first in most negative remaining available water for its three-year rolling average in peak depletive/consumptive loss. As sea level rise was not identified as a significant widespread concern for this HUC11, primary vulnerability for this HUC11 is from potential population growth and meeting future water demands.
- **02040206180 (Menantico Creek)**: includes two focus municipalities (Vineland City and Millville City), which were both identified as promising areas of growth in Cumberland County. Partially located in Water Supply Critical Area 2, this HUC11 had the third highest five-year average water withdrawals by water use category and third most negative remaining available water value for its three-year rolling average in peak depletive/consumptive loss. Among the focus municipalities, Millville City had the second largest number of Overburdened Community census blocks projected to be inundated from sea level rise.
- **Bridgeton City**: USGS reported significant water declines in the Piney Point Aquifer around Bridgeton City wells, which was anticipated to become worse in different 2040 water loss scenarios. The Piney Point Aquifer is experiencing some decline based on well water level changes, which may result in challenges for Bridgeton if its population grows as projected. Bridgeton also faces potential vulnerability from sea level rise, as Bridgeton City was found to have the largest number of Overburdened Community census blocks that would be inundated by sea level rise among the focus municipalities.
- **Salem City**: Among the focus municipalities, Salem City was found to have the third largest number of Overburdened Community census blocks projected to be inundated with two and five feet of sea level rise. Its major PCWS, Salem WD, was also projected to have almost half of its purveyor service area inundated with two feet of sea level rise – the largest inundation among major PCWSs servicing WMA17.
- **Gloucester County WMA17 Municipalities**: Gloucester County was anticipated to experience the most population growth out of the four WMA17 counties, with an MPO projected population growth of 12,977 among its WMA17 municipalities between 2020-2050. Several

major PCWSs that service HUC11s containing WMA17 Gloucester municipalities were projected to have demand increase or experience deficit by 2050.

Table J13 shows potential management options for the WMA17 region. This table is designed to include both strategies that can be applied across WMA17 and more focused strategies that can address specific localized needs. While only a few areas were highlighted in the region, these management options can be implemented in similar regional locations facing similar challenges. This section is designed to serve as a flexible blueprint for management options since each area will differ on strategies that best address their individual water supply challenges and should be monitored closely and updated as new research and data become available.

Vulnerable WMA17 Area	Encouragement of Water Saving Strategies and Improving Water Use Efficiency	Further Assessment of WMA17 PCWSs to Meet Future Regional Water Demand	Investment to Protect and Restore Aquifer Recharge	Alterations to Agriculture BMPs	Investment in Resilience and Mitigation Strategies to Reduce/Prevent Inundation of PCWS Service Areas from Sea Level Rise
02040206030	Yes	Yes	Yes	No	Yes
02040206080	Yes	Yes	No (monitor to prevent future recharge losses)	Yes	No
02040206180	Yes	Yes	Yes	Yes	Yes
Bridgeton City	Yes	Yes	Yes	No	Yes
Salem City	Yes	Yes	Yes	No	Yes
Gloucester WMA17 Municipalities	Yes	Yes	No (monitor to prevent future recharge losses)	No	No

Table J13. Potential Management Options for WMA17

The first management option (Encouragement of Water Saving Strategies and Improving Water Use Efficiency) is applicable for the entire WMA17 region and for this reason is labeled yes for all of the vulnerable WMA17 areas. Encouragement of water saving strategies can ensure water is available for both current citizens and regional goals for development. This was argued in Salem County's 2014-2017 Economic Strategic Plan, which argued that water conservation, re-allocation, and recycling are critical for ensuring water supply is available for new businesses and industry (Salem County & Salem County Improvement Authority, 2019). Encouragement of strategies promoting water use efficiency can be applied on both a local (installation of water efficient plumbing, smart irrigation systems, etc.) and regional (encouraging use of existing water supply and sewer infrastructure) scale. Efficiency in water use has been found to be associated with population density, as lower density residential water demands have been found to be higher compared to more populated areas (Van Abs et al., 2018). Recommendations for using pre-existing infrastructure, such as water and sewer, were found in planning documents for all four WMA17 counties (Simone Collins Landscape Architecture & Reed Group, 2011; Heyer, Gruel & Associates and Michael Baker International, 2018a; Cumberland County Improvement Authority, 2020; Salem County Planning Board, 2016; DVRPC, 2015) and can be critical for

balancing water demands and protecting environmental resources subject to Water Supply Critical Area 2, Pinelands Commission, and CAFRA regulations.

The second option (Further Assessment of WMA17 PCWSs to Meet Future Regional Water Demand) is recommended for all WMA17 PCWSs and is labeled yes for all of the WMA17 vulnerable areas identified in Table J13. As was found in Section 8, despite roughly half of WMA17's PCWSs being projected to experience demand decline, several PCWSs were projected to experience demand increase and have potential concerns in meeting future water demands. Planning efforts can be made to further assess WMA17 PCWS potential management options and their feasibility for meeting future demands if they run into deficit (such as bulk transfers from other PCWSs, existing infrastructure for interconnections between PCWSs, identification of alternative water sources, etc.). This assessment can also build from earlier NJDEP PCWS research, such as the 2007 NJDEP Interconnection Study (NJDEP, Gannett Fleming, & Black & Veatch, 2007). Specific focus can be placed on identifying PCWSs that are most isolated (in terms of connecting to other PCWSs and their purveyor service areas) and contain socially vulnerable populations in their service areas, and developing potential strategies if those PCWSs face deficit. Collaboration with PCWSs can strongly assist in these efforts and provide early identification of potential problems for PCWSs to respond to deficit, which may help to streamline regional response to deficit if it occurs in the future.

Investment to protect and restore aquifer recharge can be an option for urbanized locations in HUC11:02040206030, HUC11:02040206180, Bridgeton City, and Salem City, especially since urbanized locations such as Vineland City, Bridgeton City, and Millville City have been found to have impervious surface amounts that are considered harmful to their local waterways. Although it is not recommended for HUC11:02040206080 and Gloucester's WMA17 municipalities to invest to decrease impervious surfaces at this time, it is recommended that these locations proactively mitigate impervious surface development and the loss of aquifer recharge areas in the future. Actions that can be used to reduce impervious cover could include (but are not limited to): (a) de-paving; (b) use of permeable pavement systems; (c) rain garden/bioretention system installation; (d) rainwater harvesting; and (e) use of bioswale, planter boxes, and stormwater planters (Rutgers Cooperative Extension Water Resources Program, 2018b). To protect groundwater sources, regional growth and land use decisions should be closely monitored (NJ Division of Fish and Wildlife, 2004). In cases where development does occur, strategies to minimize impervious surfaces can be used, such as disconnecting runoff flow over impervious surfaces, maximizing natural drainage and vegetation, protecting areas with water quality benefits or areas vulnerable to erosion, minimizing land disturbance, and providing vegetated open-channel conveyance systems (Sickels & Associates, Inc., 2021).

Alterations to agricultural Best Management Practices (BMPs) is suggested for HUCs 02040206080 and 02040206180, which were each found to have agriculture and irrigation as a significant water withdrawal water use category over a five-year period (2016-2020) and their largest water use loss group during their respective three-year rolling averages in peak depletive/consumptive loss. Working with farmers is essential to protect regional water availability and provides one of the best opportunities for ensuring adequate open space that can be used for aquifer recharge. Several options for improving agricultural practices could include implementing strategies to increase overall participation in BMPs and improving water monitoring of agricultural lands. For example, farmers that sign up for BMPs or implement new water monitoring strategies could receive priority access to irrigation water (Morris Land Conservancy & Salem County Open Space Advisory Committee, 2006). Such an approach can also be used to determine acceptance and quantity permitted in water allocation permits.

Investment in resilience and mitigation strategies to reduce/prevent inundation of PCWS service areas from sea level rise is recommended for all PCWSs in all the identified vulnerable WMA17 areas with the

exception of HUC11:02040206080 and the more inland Gloucester WMA17 municipalities. Certain locations were identified as particularly vulnerable to sea level rise, such as Salem City and 02040206030's Carney's Point Township, and PCWSs in these locations should be prioritized in these management strategies. Increasing shoreline resilience may be critical for PCWSs with service areas in coastal areas as most of the WMA17 coastal municipalities along the Delaware River and Bay are anticipated to experience the most severe inundation from sea level rise. Some regional efforts are already underway that may decrease WMA17 PCWS vulnerability to climate change, including: (a) the promotion of wetlands protection; (b) working with FEMA, State of New Jersey, and Army Corps of Engineers to mitigate flooding in coastal areas; (c) helping to target funding for storm surface barriers and beach replenishment including living shoreline approaches; and (d) identifying pump station locations and flood mitigation strategies (SJEDD, 2021). Another potential project to decrease regional vulnerability to sea level rise is to restore and stabilize the mouth of the Maurice River – which may help decrease future inundation of Millville WD's purveyor service area. This proposed project intends to dredge the channel and includes establishing breakwaters and an oyster reef (NJ Delaware Bayshore Council, 2019).

PCWS strategies could also be developed in tandem with repeated monitoring and updating of county Multi-Hazard Mitigation reports. At the time of this assessment, all four WMA17 counties had Multi-Hazard Mitigation reports that considered county and municipality infrastructure risk from factors such as flooding, sea level rise, and severe weather events. Analysis tools from these documents, such as ranking of hazards and potential displaced populations calculations, are critical for determining the most vulnerable areas and can serve as a foundation for building strategies to improve regional resilience against climate change (For examples, see Cumberland County OEM & Stuart Wallace LLC, 2022 and Tetra Tech, 2022). PCWSs can have a critical role in hazard assessment and formulation of mitigation strategies related to water and sewer infrastructure and assist in regional collaboration to prevent hazards. These efforts should also include close collaboration with identified vulnerable populations in these locations. Areas, such as Bridgeton City, Millville City, and Salem City, each have vulnerable populations that face significant threats from sea level rise inundation and should be kept updated as new data and research on climate change become available.

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State of New Jersey
Department of Environmental Protection

2024 NEW JERSEY STATEWIDE WATER SUPPLY PLAN

APPENDIX K

FUTURE POTABLE WATER AVAILABILITY FOR NEW JERSEY'S PUBLIC COMMUNITY WATER SYSTEMS

FUTURE POTABLE WATER AVAILABILITY FOR NEW JERSEY'S PUBLIC COMMUNITY WATER SYSTEMS

TABLE OF CONTENTS

INTRODUCTION

The goal of the analysis is to model 2050 remaining water availability for public community water systems using current demands and surplus deficits and the result of the 2050 forecasted water demands (discussed in Appendix D and Chapter 4). Results of the analysis show areas of the State with surplus or deficit supplies in relation to currently approved supply, not natural resource capacity. This assessment, when combined with the natural resource limitations discussed in Chapters 2 and 4, provides a planning overview for determining areas of surplus and deficit in relation to approved supplies.

There are multiple data sources used to develop the analysis discussed here. Changes to any one of those datasets will change the results shown here. The analysis presented here is a snapshot based on current data where water availability concerns may exist in 2050.

PROCESS

This analysis subtracts the future water demand from a public water system's remaining available water as determined through the Bureau of Water System Engineering's Surplus/Deficit analysis. Four different future water use scenarios were utilized from a 2018 Rutgers report which was updated for the 2024 Plan with data through 2050. The remaining amount indicates whether a particular water system will have a surplus (remaining available approved supply) or a deficit (shortage of approved supply) for their identified water service area for the projected time period. Table K1 lists the data used in this analysis.

Table K1. Datasets used in the analysis.

Data Title	Provider	Description	Data Location
Public Water System surplus/deficit	DEP/Bureau of Water System Engineering	Current water allocation surplus/deficit data for each water purveyor	DEP DWSG Public Water System Deficit/Surplus website
2050 Forecast Water Demands for New Jersey Public Community Water Supply Systems	**Rutgers** – The State University of New Jersey School of Environmental and Biological Sciences	Projected water demand based upon population projections for each municipality to 2050	Data available in NJSWSP 2024 Appendix D
New Jersey Municipal Boundaries	DEP/GIS	2009 New Jersey Municipal Boundaries	DEP Bureau of GIS New Jersey Municipal Boundaries
PWS Service Area Boundaries	DEP/GIS	1998 mapping available, internal deliberative revised dataset used in this analysis	DEP Bureau of GIS PWS Service Areas

ASSUMPTIONS

1. The analysis uses the Public Water System Deficit/Surplus data that was current as of (06/2021). This information is periodically updated and any changes to that dataset could results in changes to these results. Refer to the DEP Firm Capacity and Water Allocation Analysis pdf for details on this method.
2. Many small water systems do not have a surplus/deficit calculated for them and others do not have a mapped service area available. For those systems, a current surplus of zero was assumed.
3. Municipalities without a purveyor population served were assumed to not have a water system now or in the future.
4. The analysis assumes no changes to water supply infrastructure or additional permitted allocations (new or expanded sources of supply) in order to estimate the most conservative scenario for public water systems.
5. All projected population growth is assumed to be served by a public water system in future growth calculations.
6. Commercial demands are assumed to mirror the rate of Residential demands, and Industrial demands were held constant. These assumptions are not entirely correct but likely close enough for the modeling process.
7. Water loss is typically referred to as either non-revenue water or unaccounted for water. Although there are different ways of calculating water loss, it can generally be thought of as the volume of produced water that does not reach a purveyor customer base. In this analysis the rate of water loss is projected to 2050 in two different scenarios, both based on the findings of the Rutgers report, which examined the most recent reported water loss data available at the time. The nominal water loss scenario holds water loss at the median level of reported non-revenue water while the optimal water loss scenario assumes that all systems achieve water loss rates equivalent to the 25th percentile levels seen in the data (better systems), an aggressive assumption. It is important to note that due to the many variables that exist it is nearly impossible to project water loss rates over decades of time. Consequently, these should be considered general estimates that include substantial uncertainty.
8. The total modeled water demands incorporate Residential, Industrial and Commercial (RIC) demands plus water losses.

METHODOLOGY

The analysis required multiple steps, described below. Some datasets required manipulation so that they could be used in this analysis. The required inputs were: population growth for each municipality, and current surplus/deficit for each water purveyor. Figure K1 is a schematic of the analysis process.

STEP 1

The first step of the analysis to collect the surplus/deficit data and convert them into mgd for each water purveyor. The first input for this analysis was the current (2021) surplus or deficit for each purveyor. Public water system surplus/deficit results are determined from an analysis done by the Division of Water Supply and Geoscience’s Bureau of Water System Engineering. 583 public community water systems are

included in their current surplus/deficit analysis of which 82 do not have any surplus/deficit information available because of their small size and falling under reporting limits.

The surplus/deficit analysis and resulting summary table contains three values which were utilized in this analysis: Water Allocation Monthly Average Daily Demand (MADD), and Water Allocation Annual Average Daily Demand (AADD). The MADD and AADD values are based on existing water allocation permit limits and bulk purchase contracts. More information of this process can be found in the following document: DEP Firm Capacity and Water Allocation Analysis pdf.

The current surplus/deficit for each water purveyor was determined by finding the most limiting value from the MADD or AADD which was converted to mgd. The conversion process is shown in the Table K2. All remaining systems without a surplus/deficit determination were assumed to have a *surplus* of 0 mgd in the model. After this process was completed, every system had a "*surplus/deficit"* value in mgd. These values are the Current Baseline for the analysis.

Table K2. Unit Conversions.

Surplus/Deficit	Original Units	Conversion
MADD	mgm	Divide by 31
AADD	mgy	Divide by 365

Shorelands Water Company (#1339001) is included below in Table K3 to further clarify the conversion process.

Table K3. Example of conversion process for a purveyor.

WSID#	Surplus/Deficit mgm	Surplus/Deficit mgy	mgm to mgd	mgy to mgd	Current Surplus/Deficit mgd
1339001	227.4	1802.5	7.3	4.9	0.3

STEP 2

The next step into the analysis is to gather average observed demand data for each water purveyor. Average observed data were generated using New Jersey Water-Transfer Data System (NJWaTr) database for each purveyor. NJWaTr is database system that compiles, stores, and distributes New Jersey's water use data for research and modeling purposes. For this analysis, observed data from the 2016-2020 period were used to generate an Average Observed Demand value in mgd for each purveyor.

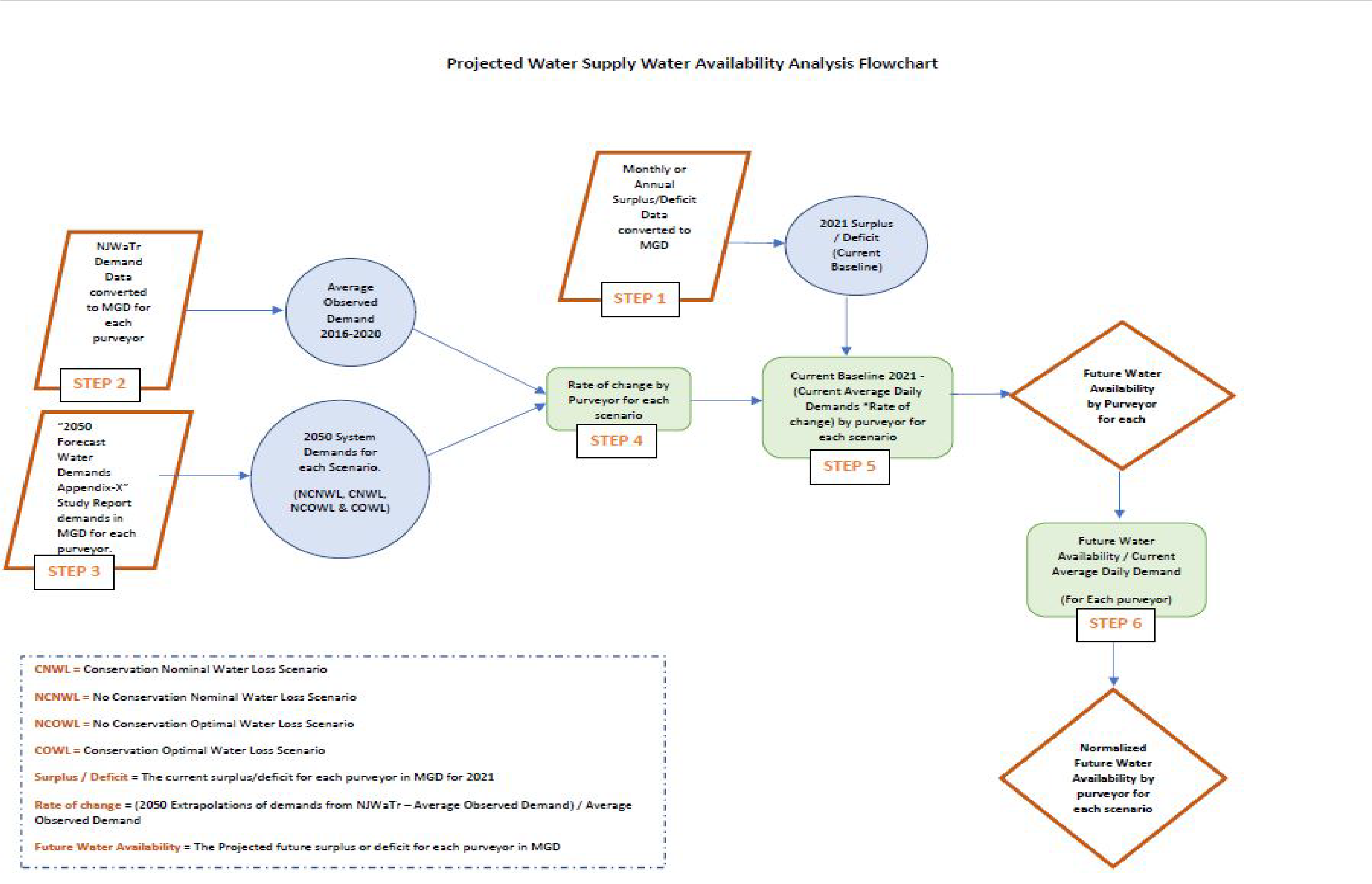


Figure K1. Projected Water Supply Water Availability Analysis Flowchart

STEP 3

In this step of the analysis, 2050 forecasted demand data were compiled from the Rutgers Report. Four scenarios were selected from the report and the 2050 demand data was gathered for each scenario for each purveyor. The four scenarios incorporated different combinations of two options for the rate of water loss (typically referred to as either non-revenue water or unaccounted for water) and two options for the rate of conservation, all of which are detailed below.

1. **Nominal Water Loss**: water loss held at the current median levels based on current analysis of all systems in New Jersey that reported at the time of the NJSWSP
2. **Optimal Water Loss**: water loss rates for all systems equivalent to the current 25th percentile for all systems in New Jersey that reported at the time of the NJSWSP
3. **No Conservation scenario**: residential per capita and commercial demand rates not impacted by conservation practices
4. **Conservation scenario**: residential rates do decline gradually (10% reduction by 2050)

Based on the possible combinations of different options described above, the four scenarios that were selected for this analysis are provided below.

1. **CNWL** = Conservation Nominal Water Loss Scenario
2. **NCNWL** = No Conservation Nominal Water Loss Scenario
3. **NCOWL** = No Conservation Optimal Water Loss Scenario
4. **COWL** = Conservation Optimal Water Loss Scenario

After choosing the above mentioned four scenarios, 2050 system demands were collected for each purveyor for each scenario.

STEP 4

The next phase of the analysis determined the projected growth factor for each system in each scenario. The growth factor is the percent difference between the initial baseline and final estimation.

$$\textbf{Growth Factor} = \frac{\text{(2050 system demand – Average Observed Demand)}}{\text{Average Observed Demand}}$$

STEP 5

The last part of the analysis determined the net future availability for each purveyor for 2050. The growth factor was multiplied by the current average daily demand resulting in an estimate of 2050 demand that was then subtracted from the current surplus/deficit value. This produced a value representing the predicted amount of surplus/deficit per system (future water available) for each purveyor for each scenario. The final surplus/deficit for each system was then mapped by linking the data to the drinking water service area boundaries using the Public Water System Identification Database (PWSID). The same example of Shorelands Water Company (#1339001) is included below in Table K4 to illustrate each step of the analysis.

Table K4. Example of future 2050 future water availability calculation.

PWSID#	Growth Factor	Current Baseline Surplus/Deficit (mgd)	Average Daily Demand (mgd)
1339001	-0.090102	0.301205	4.9382

Future Water Availability 2050 for Shorelands Water Company (PWSID1339001) is calculated as follow:

0.301205 - (4.9382*-0.090102) = 0.7461 mgd

STEP 6

The future water availability by water purveyor is an important piece of information for any one purveyor. However, the relative water availability between different purveyors can be misleading. For example, a water system with a large population served and surplus of only 1 mgd needs to be considered differently than a very small system with the same 1 mgd of availability. In other words, 1 mgd for a small system may be more than adequate to meet any future growth, but for a large system it would not be adequate.

To address this shortcoming, the future water availability for a system was divided by its current average daily demand. This resulted in a normalized future water availability that is a better metric for comparing one system to another.

Table K5. Example of future 2050 Normalized future water availability calculation.

PWSID#	Growth Factor	Current Baseline Surplus/Deficit (mgd)	Future Water Availability (mgd)
1339001	0.086116	0.301205	0.7461

Normalized Future Water Availability 2050 for Shorelands Water Company (#1339001) is calculated as follow:

0.7461 / 0.301205 = 2.477

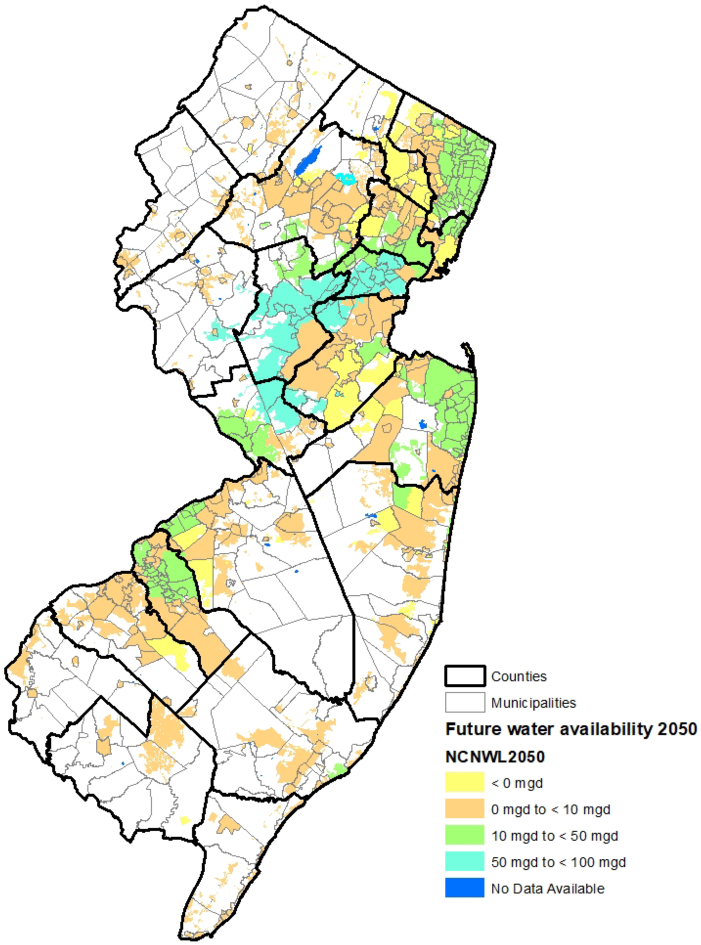
FINDINGS AND SUMMARY

Figures K2, K3, K4 and K5 show water purveyors with their corresponding deficit/surplus (left side) and the normalized future water availability (right side) for the 2050 projection periods. The normalized graphics enable comparison between systems by converting the deficit/surpluses into percentages relative to a system's current demand. Thus, comparison becomes possible despite differences of

magnitude between larger vs smaller systems. Table-K6 shows water purveyors with their corresponding deficit/surplus and the normalized future water availability for the 2050 projection periods.

This analysis identifies water purveyor's future water availability based upon projected population growth. It identified both systems with and without adequate approved supply to satisfy projected population growth. While the uses of such an assessment need to be evaluated with the understanding that permit modifications or demand changes can alter the results, it is a useful statewide analysis to aid in identifying areas where there is currently available approved supply and those areas that are currently or are projected to require additional sources of supply. However, as indicated at the beginning of this appendix, it is important to consider the natural capacities of those areas, since areas with excess supply may have limitations to the sustainability of the excess.

Figure K2a. (left) shows the projected 2050 water availability by public water system for the No Conservation Nominal Water Loss Scenario (NCNWL).
Figure K2b. (right) shows the projected 2050 water availability normalized by 2021 average daily demand for the NCNWL scenario.



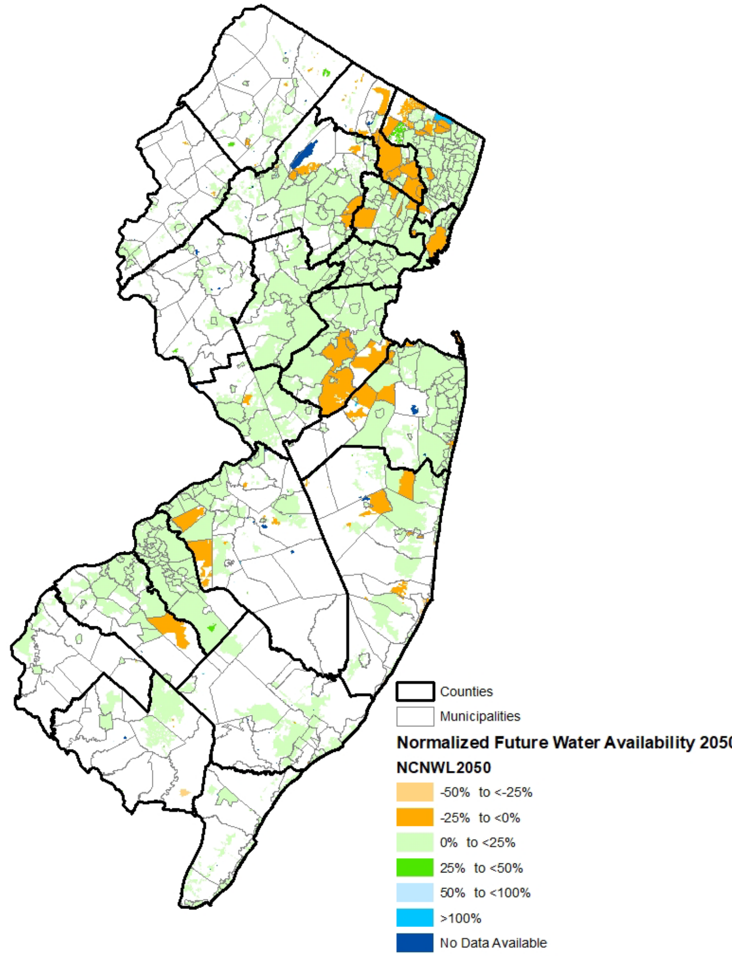
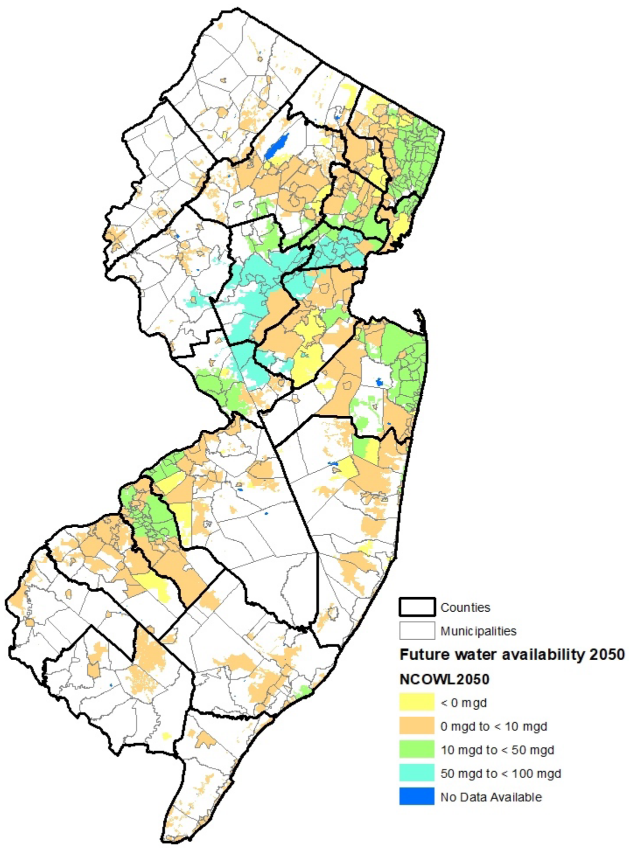


Figure K3a. (left) shows the projected 2050 water availability by public water system for the No Conservation Optimal Water Loss Scenario (NCOWL).
Figure K3b. (right) shows the projected 2050 water availability normalized by 2021 average daily demand for the NCOWL scenario.



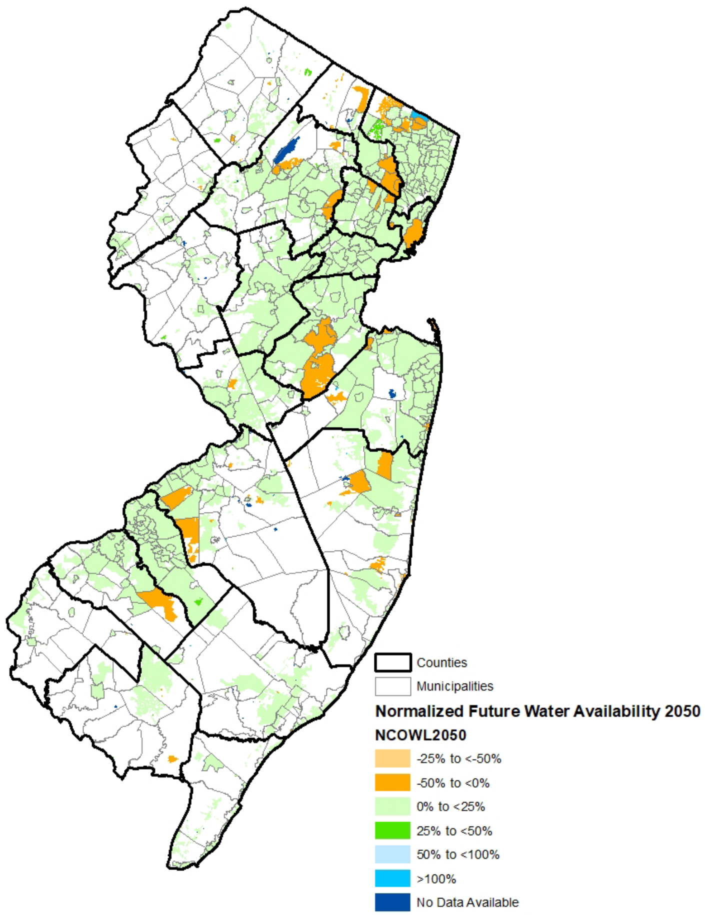


Figure K4a. (left) shows the projected 2050 water availability by public water system for the Conservation Nominal Water Loss Scenario (CNWL).
Figure K4b. (right) shows the projected 2050 water availability normalized by 2021 average daily demand for the CNWL scenario.

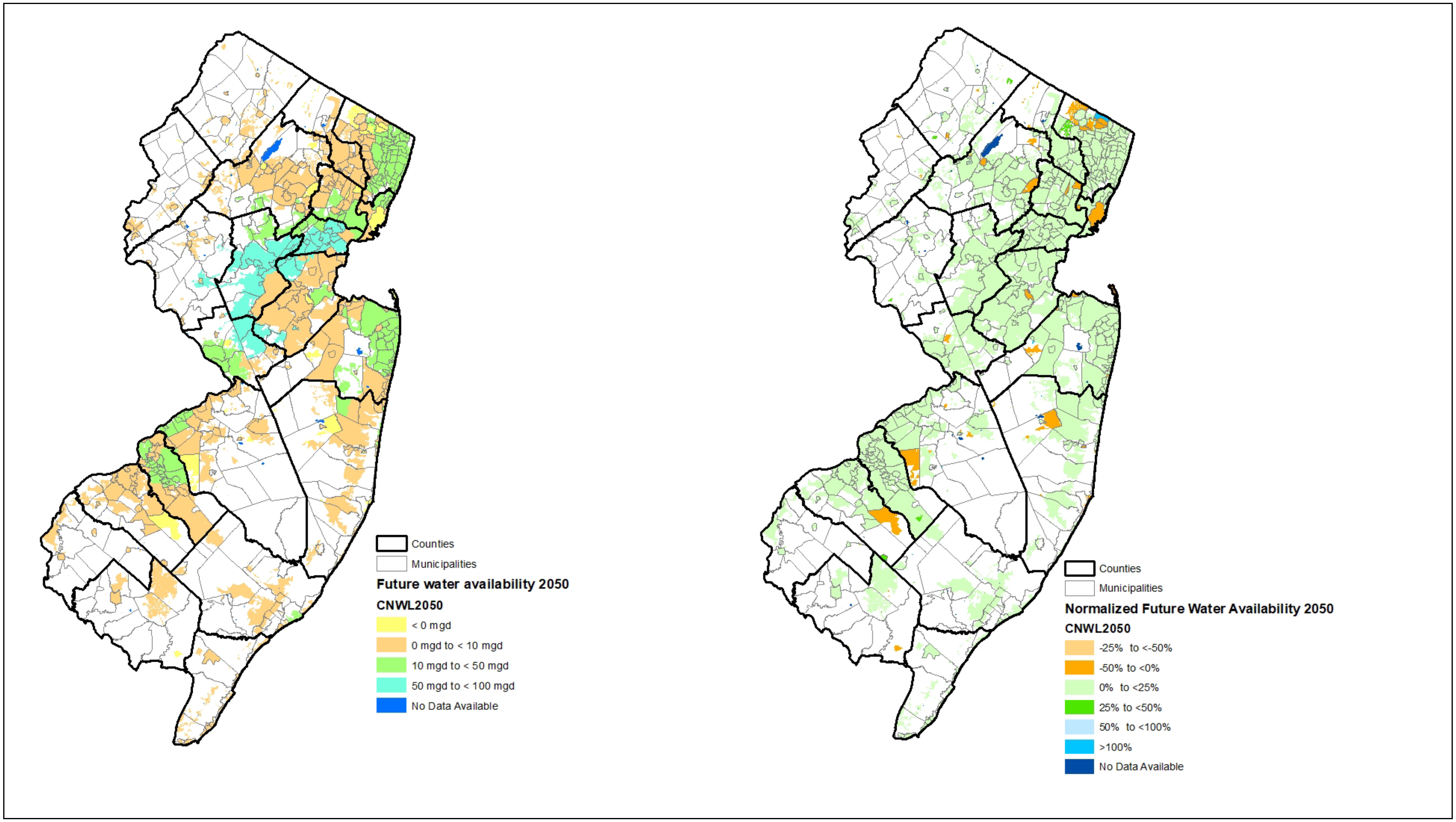
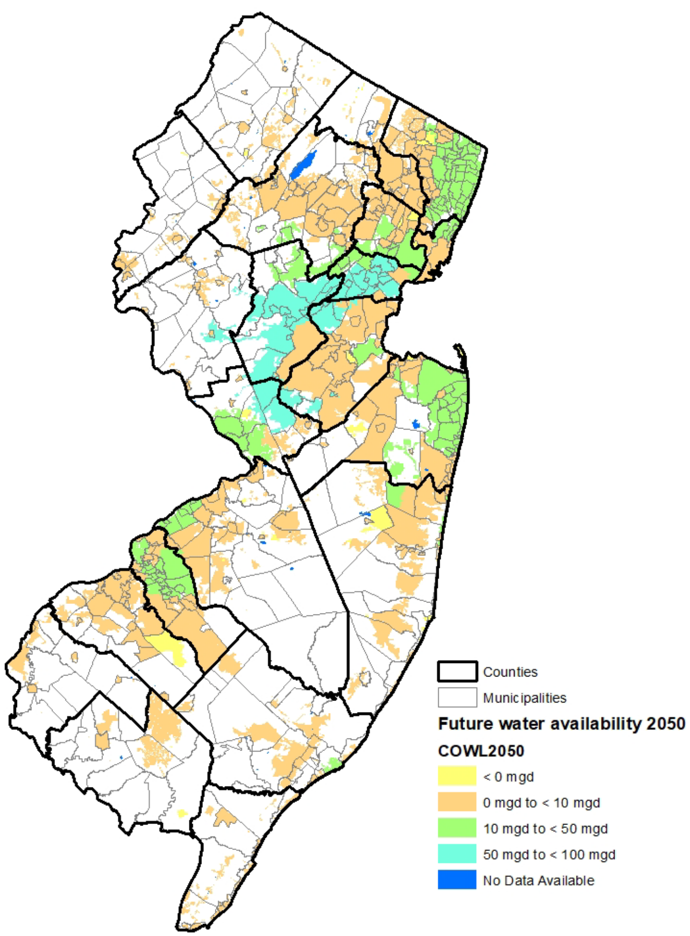


Figure K5a. (left) shows the projected 2050 water availability by public water system for the Conservation Optimal Water Loss Scenario (COWL).
Figure K5b. (right) shows the projected 2050 water availability normalized by 2021 average daily demand for the COWL scenario.



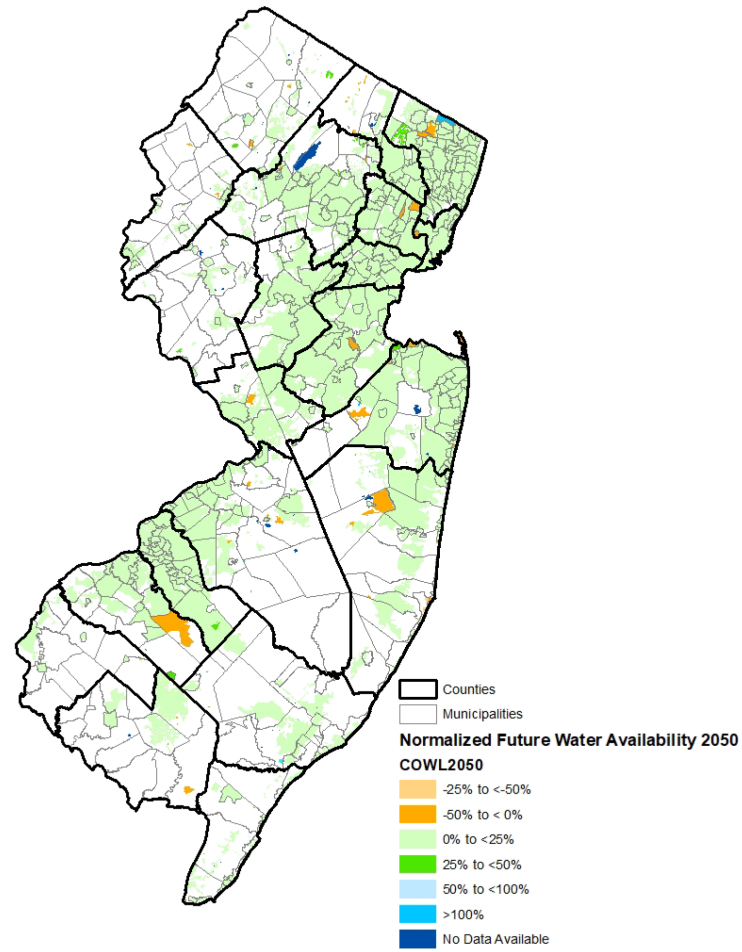


Table K6. Purveyors with 2021 surplus/deficit, Projected 2050 Future Water Availability and Normalized Water Availability

PWSID	PWSID NAME	2021 Deficit/ Surplus	Future Water Availability for 2050 (mgd) NCNWL	NCOWL	CNWL	COWL	Normalized Water Availability for 2050 (-) NCNWL	NCOWL	CNWL	COWL
NJ0102001	ATLANTIC CITY MUA	12.56	12.61	13.06	13.67	14.08	1.18	1.22	1.28	1.32
NJ0103001	BRIGANTINE WATER DEPARTMENT	0.55	0.17	0.26	0.39	0.47	0.10	0.15	0.22	0.26
NJ0104003	BUENA BOROUGH MUA	0.12	0.08	0.11	0.14	0.16	0.16	0.20	0.26	0.30
NJ0105001	BUENA FAMILY MANOR MOBILE H P	0.09	0.09	0.09	0.09	0.09	13.95	14.00	14.06	14.10
NJ0105002	GARDEN HOMES MANAGEMENT CORPORATION	0.07	0.07	0.07	0.07	0.07	3.99	4.04	4.09	4.13
NJ0107001	EGG HARBOR CITY WATER DEPT	0.19	0.18	0.20	0.22	0.23	0.56	0.60	0.66	0.70
NJ0108002	ENGLISH CREEK MANOR M H PARK	0.07	0.07	0.07	0.07	0.08	3.84	3.88	3.93	3.96
NJ0108003	TILTON TERRACE MH	0.00	0.00	0.00	0.00	0.00	-0.10	-0.05	0.00	0.04
NJ0108004	NORMS DALE MOBILE HOME PARK	0.06	0.06	0.06	0.06	0.06	2.80	2.84	2.89	2.92
NJ0108005	AQUA NJ - SEAVIEW HARBOR	0.06	0.03	0.04	0.04	0.04	1.55	1.63	1.75	1.83
NJ0108006	TOWER MOBILE HOMES	0.08	0.08	0.08	0.08	0.08	6.56	6.60	6.65	6.69
NJ0108009	STONEY FIELD MOBILE HOME PARK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0108013	TOWER 1999 MOBILE HOME PARK	0.07	0.07	0.07	0.07	0.07	2.65	2.68	2.73	2.77
NJ0108014	TOWER EAST MOBILE HOME PARK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0108019	OAK FOREST MOBILE HOME PARK	0.04	0.04	0.04	0.04	0.05	1.34	1.38	1.43	1.46
NJ0108023	EGG HARBOR RIVER RESORT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0108303	BAY BREEZE VILLAGE	0.10	0.10	0.10	0.10	0.10	112.72	112.79	112.89	112.96
NJ0111004	POMONA MOBILE HOME PARK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0111006	SHADY PINES CAMPING RESORT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0111007	SWAN LAKE RESORT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

PWSID	PWSID NAME	2021 Deficit/ Surplus	Future Water Availability for 2050 (mgd)				Normalized Water Availability for 2050 (-)			
			NCNWL	NCOWL	CNWL	COWL	NCNWL	NCOWL	CNWL	COWL
NJ0112001	HAMILTON TOWNSHIP MUA	1.16	1.21	1.29	1.40	1.48	0.60	0.64	0.70	0.74
NJ0112002	BLACK HORSE MANOR	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0113001	HAMMONTON WATER DEPT	0.47	0.35	0.41	0.49	0.55	0.27	0.32	0.38	0.42
NJ0115001	LONGPORT WATER DEPARTMENT	-0.02	-0.03	-0.02	0.01	0.03	-0.08	-0.04	0.02	0.06
NJ0116001	MARGATE CITY WATER DEPARTMENT	0.49	0.15	0.22	0.32	0.39	0.10	0.15	0.23	0.27
NJ0117001	MULLICA WOODS MOBILE HOME PARK	0.07	0.07	0.07	0.07	0.07	3.31	3.36	3.43	3.47
NJ0119001	DELILAH TERRACE MHP	0.08	0.08	0.08	0.08	0.08	4.34	4.38	4.44	4.48
NJ0119002	NJ AMERICAN WATER - ATLANTIC COUNTY	5.10	4.79	5.27	5.92	6.36	0.43	0.48	0.54	0.58
NJ0122001	VENTNOR CITY WATER & SEWER UTILITY	0.50	0.25	0.32	0.42	0.49	0.17	0.22	0.28	0.33
NJ0123001	WEYMOUTH TWSP MUA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0123002	THE OAKS OF WEYMOUTH WATER CO.	0.03	0.02	0.03	0.03	0.04	0.25	0.29	0.36	0.40
NJ0201001	ALLENDALE WATER DEPT	0.24	0.12	0.17	0.22	0.26	0.15	0.20	0.27	0.31
NJ0211001	ELMWOOD PARK WATER DEPT	0.85	0.71	0.80	0.91	0.99	0.38	0.43	0.49	0.53
NJ0217001	FAIR LAWN WATER DEPT	1.69	1.35	1.53	1.75	1.92	0.37	0.42	0.48	0.52
NJ0220001	SUEZ WATER NEW JERSEY FRANKLIN LAKES	9.56	9.21	9.32	9.45	9.55	4.45	4.50	4.57	4.61
NJ0221001	GARFIELD WATER DEPARTMENT	1.32	1.00	1.15	1.33	1.47	0.33	0.38	0.44	0.48
NJ0228001	HO HO KUS WATER DEPT	0.16	0.04	0.08	0.11	0.14	0.07	0.13	0.19	0.24
NJ0231001	PASSAIC VALLEY WC LODI WD	1.76	1.65	1.74	1.85	1.93	0.89	0.93	0.99	1.04
NJ0232001	LYNDHURST WATER DEPARTMENT	0.21	-0.08	0.06	0.22	0.34	-0.03	0.02	0.08	0.13
NJ0233001	MAHWAH WATER DEPARTMENT	0.68	-0.56	-0.35	-0.12	0.07	-0.17	-0.11	-0.04	0.02
NJ0233005	BOGERTS RANCH ESTATES IN	0.00	-0.01	-0.01	0.00	0.00	-0.41	-0.34	-0.26	-0.20
NJ0236001	SUEZ WATER NEW JERSEY MONTVALE PD95	2.76	2.73	2.74	2.75	2.76	22.31	22.37	22.43	22.48
NJ0238001	SUEZ WATER NEW JERSEY HACKENSACK	22.38	16.13	21.53	27.87	32.73	0.15	0.19	0.25	0.29
NJ0239001	PVWC-NORTH ARLINGTON	2.92	2.76	2.84	2.93	2.99	1.87	1.92	1.98	2.03

PWSID	PWSID NAME	2021	Future Water Availability for 2050 (mgd)				Normalized Water Availability for 2050 (-)			
		Deficit/ Surplus	NCNWL	NCOWL	CNWL	COWL	NCNWL	NCOWL	CNWL	COWL
NJ0242001	OAKLAND WATER DEPT	0.41	-0.03	0.07	0.18	0.27	-0.02	0.04	0.11	0.16
NJ0247001	PARK RIDGE WATER DEPT	0.09	-0.37	-0.24	-0.10	0.01	-0.17	-0.11	-0.05	0.00
NJ0248001	RAMSEY WATER DEPT	1.47	1.01	1.12	1.24	1.34	0.55	0.60	0.67	0.72
NJ0251001	RIDGEWOOD WATER	2.22	0.81	1.25	1.78	2.19	0.10	0.15	0.21	0.26
NJ0257001	SADDLE BROOK WATER DEPT	0.19	0.00	0.08	0.17	0.24	0.00	0.05	0.11	0.16
NJ0258001	SADDLE RIVER WATER UTILITY	-0.15	-0.19	-0.17	-0.16	-0.15	-0.85	-0.79	-0.73	-0.68
NJ0264001	WALDWICK WATER DEPT	0.14	-0.23	-0.17	-0.09	-0.03	-0.22	-0.16	-0.09	-0.03
NJ0265001	WALLINGTON WATER DEPT	0.88	0.69	0.75	0.81	0.86	0.67	0.73	0.79	0.84
NJ0301001	BUTTONWOOD MOBILE HOME PARK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0303001	BORDENTOWN WATER DEPARTM	0.85	0.68	0.77	0.91	1.00	0.32	0.36	0.43	0.47
NJ0305001	BURLINGTON CITY WATER DEPT	0.84	1.11	1.15	1.20	1.24	0.91	0.94	0.99	1.02
NJ0306001	BURLINGTON TWP W DEPT	0.91	0.95	1.04	1.16	1.24	0.45	0.49	0.55	0.59
NJ0307002	ALBERT C WAGNER YOUTH CORRECTIONAL FACILITY	0.29	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0311001	FENIMORE TRAILER PARK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0311002	FENIMORE WOODS MHP	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0313001	EVESHAM MUA	0.05	-0.49	-0.30	-0.05	0.11	-0.13	-0.08	-0.01	0.03
NJ0314001	FIELDSBORO WATER DEPARTMENT	0.08	0.08	0.08	0.08	0.08	N/A	N/A	N/A	N/A
NJ0315001	FLORENCE TWP W DEPT	0.16	0.17	0.24	0.33	0.40	0.10	0.14	0.20	0.24
NJ0318002	NJ AMERICAN WATER - HOMESTEAD	0.03	-0.04	-0.03	-0.02	-0.01	-0.23	-0.18	-0.09	-0.04
NJ0319001	MAPLE SHADE WATER DEPARTMENT	0.16	0.50	0.57	0.65	0.71	0.27	0.30	0.35	0.38
NJ0320001	MEDFORD TWP DEPT OF MUNI	0.70	0.56	0.63	0.73	0.79	0.37	0.42	0.48	0.52
NJ0320002	ESTAUGH CORP T/A MEDFORD LEAS	0.00	-0.03	-0.03	-0.02	-0.02	-0.41	-0.35	-0.27	-0.22
NJ0322001	MOORESTOWN WATER DEPT	0.23	-0.26	-0.10	0.11	0.25	-0.08	-0.03	0.03	0.08
NJ0323001	NJ AMERICAN WATER - MOUNT HOLLY	1.94	1.63	1.84	2.12	2.31	0.36	0.40	0.46	0.50

PWSID	PWSID NAME	2021 Deficit/ Surplus	Future Water Availability for 2050 (mgd)				Normalized Water Availability for 2050 (-)			
			NCNWL	NCOWL	CNWL	COWL	NCNWL	NCOWL	CNWL	COWL
NJ0324001	MT LAUREL TWP MUA	0.19	0.10	0.30	0.57	0.75	0.02	0.07	0.12	0.16
NJ0325001	JBMDL-DIX MAIN SYSTEM	2.97	4.04	4.07	4.11	4.14	2.27	2.29	2.31	2.33
NJ0326001	AQUA NJ - CALIFORNIA VILLAGE	0.07	0.07	0.07	0.07	0.07	N/A	N/A	N/A	N/A
NJ0326003	HANOVER EAST APARTMENTS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0326004	AQUA NJ - HANOVER MOBILE VILLAGE	0.04	0.01	0.01	0.02	0.02	0.26	0.34	0.43	0.50
NJ0326005	CEDAR GROVE APARTMENTS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0326006	JOINT BASE MDL MCGUIRE AREA	0.47	0.47	0.50	0.54	0.57	0.65	0.69	0.75	0.79
NJ0326007	SOUTHS MOBILE HOME PARK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0326008	AQUA NJ INC - SPARTAN VILLAGE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NJ0326009	WAGON WHEEL ESTATES	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0326012	MILLSTREAM APTS	0.08	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0326013	MILLSTREAM APTS	0.04	0.04	0.04	0.04	0.04	3.09	3.15	3.23	3.28
NJ0326014	FAMILY PARK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0327001	NJ AMERICAN WATER - WESTERN DIVISION	23.36	23.41	25.27	27.77	29.45	0.53	0.58	0.63	0.67
NJ0328001	PEMBERTON BOROUGH WATER	0.08	0.08	0.09	0.10	0.10	0.59	0.63	0.69	0.73
NJ0329001	BURLINGTON COUNTY INSTIT	-0.02	-0.04	-0.03	-0.03	-0.02	-0.51	-0.45	-0.38	-0.33
NJ0329002	HILLTOP MOBILE VILLAGE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0329003	PEMBERTON TOWNSHIP WATER - LAKE VALLEY	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0329004	PEMBERTON TWP DEPT MAIN	0.69	0.68	0.71	0.76	0.78	0.88	0.93	0.99	1.02
NJ0329005	PINEVIEW TERRACE INCORPORATED	0.03	0.02	0.02	0.02	0.03	0.95	1.01	1.08	1.14
NJ0329006	NJ AMERICAN WATER - SUNBURY	0.05	0.05	0.05	0.05	0.06	0.63	0.68	0.74	0.77
NJ0329008	PINEFIELD APARTMENTS	0.09	0.09	0.09	0.09	0.09	11.65	11.71	11.79	11.84
NJ0329009	PEMBERTON TWP WATER DEPT - PEMBERTON HEIGHTS	-0.07	-0.06	-0.06	-0.06	-0.06	-2.35	-2.31	-2.26	-2.22

PWSID	PWSID NAME	2021 Deficit/ Surplus	Future Water Availability for 2050 (mgd) NCNWL	NCOWL	CNWL	COWL	Normalized Water Availability for 2050 (-) NCNWL	NCOWL	CNWL	COWL
NJ0332001	FAWN LAKE VILLAGE	0.07	0.07	0.07	0.07	0.07	4.24	4.29	4.37	4.41
NJ0332002	OAKVIEW LEISURE VILLAGE	0.08	0.08	0.08	0.08	0.08	5.63	5.68	5.75	5.80
NJ0333001	PINELANDS WATER CO	0.27	0.24	0.26	0.29	0.30	0.58	0.63	0.69	0.73
NJ0333002	MOBILE ESTATES OF SOUTHA	0.02	0.02	0.02	0.03	0.03	0.35	0.39	0.45	0.48
NJ0333003	RICHARDS MOBILE HOME COURT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0333004	NJ AMERICAN WATER -VINCENTOWN	0.04	0.04	0.05	0.05	0.05	0.93	0.97	1.03	1.07
NJ0335001	ALLENWOOD MOBILE ESTATES	0.09	0.09	0.09	0.09	0.09	19.52	19.57	19.62	19.66
NJ0338001	WILLINGBORO MUA	1.75	2.18	2.32	2.51	2.63	0.58	0.62	0.67	0.71
NJ0339001	NEW LISBON DEVELOPMENT CTR	0.11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0340001	WRIGHTSTOWN MUA	0.10	0.07	0.07	0.08	0.08	1.09	1.15	1.24	1.29
NJ0340002	MAPLEWOOD APARTMENTS	0.08	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0404001	BELLMAWR WATER DEPT	0.11	0.15	0.19	0.23	0.26	0.18	0.22	0.27	0.31
NJ0405001	BERLIN WATER DEPARTMENT	0.37	0.31	0.35	0.40	0.44	0.38	0.42	0.48	0.52
NJ0407001	BROOKLAWN WATER DEPARTMENT	0.06	0.04	0.04	0.06	0.06	0.20	0.25	0.31	0.35
NJ0408001	CITY OF CAMDEN	7.68	10.49	10.84	11.32	11.64	0.94	0.97	1.02	1.05
NJ0410001	TOWN & COUNTRY MHP	0.08	0.08	0.08	0.08	0.08	5.18	5.24	5.31	5.37
NJ0410002	BNAI BRITH CHESILHURST HOUSE	0.09	0.09	0.09	0.09	0.09	29.80	29.80	29.80	29.80
NJ0411001	CLEMENTON WATER DEPARTMENT	0.35	0.38	0.40	0.43	0.45	0.72	0.76	0.82	0.85
NJ0412001	COLLINGSWOOD WATER DEPAR	0.17	0.34	0.41	0.52	0.58	0.17	0.21	0.26	0.30
NJ0414001	GLOUCESTER CITY WATER DEPARTMENT	0.56	0.59	0.62	0.67	0.70	0.70	0.74	0.80	0.83
NJ0415002	AQUA NJ - BLACKWOOD	1.11	0.87	1.04	1.27	1.43	0.23	0.28	0.34	0.38
NJ0416001	HADDON TWP WATER DEPARTM	0.31	0.41	0.45	0.50	0.53	0.42	0.46	0.51	0.54
NJ0424001	MERCHANTVILLE PENNSAUKEN	1.22	1.37	1.62	1.96	2.19	0.22	0.27	0.32	0.36
NJ0428002	PINE HILL BOROUGH MUA	0.62	0.59	0.63	0.67	0.70	0.74	0.79	0.85	0.89

PWSID	PWSID NAME	2021 Deficit/ Surplus	Future Water Availability for 2050 (mgd) NCNWL	NCOWL	CNWL	COWL	Normalized Water Availability for 2050 (-) NCNWL	NCOWL	CNWL	COWL
NJ0429001	PINE VALLEY GOLF CLUB	-0.55	-0.55	-0.55	-0.55	-0.55	-2.49	-2.49	-2.49	-2.49
NJ0435003	WATERFORD TOWNSHIP WATER DEPT.	0.41	0.36	0.37	0.38	0.39	1.59	1.64	1.71	1.76
NJ0435324	PARKWOODS CARE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0436001	ANCORA PSYCHIATRIC HOSPI	0.56	0.80	0.80	0.80	0.80	3.18	3.18	3.18	3.18
NJ0436002	ELMTOWNE VILLAGE ASSOC SYS 1	0.08	0.07	0.07	0.08	0.08	5.23	5.29	5.37	5.42
NJ0436007	WINSLOW TWP DMU	2.04	1.97	2.07	2.21	2.30	0.84	0.88	0.94	0.98
NJ0436008	WINSLOW TWP DMU	0.06	0.05	0.05	0.05	0.06	1.93	1.98	2.06	2.11
NJ0436009	ELMTOWNE VILLAGE ASSOC. SYS 2	0.08	0.07	0.07	0.08	0.08	5.23	5.29	5.36	5.42
NJ0436010	WINSLOW COURT HOMES INC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0501001	AVALON WATER AND SEWERAGE UTILITIES	0.24	0.20	0.25	0.32	0.36	0.18	0.22	0.28	0.32
NJ0502001	CAPE MAY WATER & SEWER UTILITY	0.72	0.47	0.55	0.65	0.72	0.30	0.35	0.41	0.46
NJ0503001	CAPE MAY POINT BORO WATER DEPARTMENT	0.01	0.02	0.02	0.02	0.03	0.18	0.22	0.27	0.31
NJ0504306	OCEAN VIEW ASSO OPERATION LLC DBA AUTUMN LAKE	0.07	0.07	0.07	0.07	0.07	3.45	3.49	3.55	3.59
NJ0505002	LOWER TWP MUA	0.11	0.18	0.25	0.33	0.39	0.12	0.16	0.21	0.25
NJ0505003	CAPE MAY MOBILE ESTATES	0.07	0.07	0.07	0.07	0.07	8.28	8.34	8.41	8.46
NJ0506001	DELSEA WOODS COMMUNITY LLC	0.07	0.07	0.07	0.07	0.07	3.86	3.91	3.97	4.02
NJ0506004	EDGEWOOD VILLAGE M H PARK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0506007	GRANDE WOODS SOUTH MOBILE H P	0.05	0.05	0.05	0.05	0.06	1.59	1.63	1.68	1.72
NJ0506008	MIDDLE TWP WATER DISTRICT 1	0.05	0.04	0.04	0.05	0.05	1.50	1.56	1.63	1.68
NJ0506009	MIDDLE TWP WATER DISTRICT #2	0.01	0.00	0.00	0.01	0.01	0.02	0.07	0.14	0.18
NJ0506010	NJ AMERICAN WATER - CAPE MAY COURT HOUSE	0.27	0.37	0.40	0.44	0.46	0.47	0.51	0.56	0.59
NJ0506012	PRESIDENTIAL COURTS MOBILE H P	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0506013	A AND J MOBILE HOME PARK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

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NJ0506015	GRANDE WOODS NORTH MHP	0.07	0.07	0.07	0.07	0.07	3.97	4.01	4.06	4.10
NJ0506321	CEDAR SPRINGS MHP WELL #	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0508001	NJ AMERICAN WATER - OCEAN CITY	1.21	1.12	1.25	1.41	1.52	0.40	0.45	0.51	0.55
NJ0509001	SEA ISLE CITY WATER DEPARTMENT	0.31	0.32	0.35	0.40	0.43	0.40	0.44	0.50	0.54
NJ0510001	STONE HARBOR WATER DEPT	0.14	0.12	0.15	0.18	0.21	0.21	0.25	0.31	0.35
NJ0511001	NJ AMERICAN WATER - STRATHMERE	0.03	-0.49	-0.47	-0.43	-0.41	-8.62	-8.19	-7.61	-7.23
NJ0511003	SHORE ACRES MOBILE HOME	0.06	0.05	0.05	0.05	0.05	2.31	2.36	2.43	2.48
NJ0512001	WEST CAPE MAY WATER DEPT	-0.01	0.01	0.01	0.02	0.02	0.05	0.09	0.14	0.18
NJ0514001	WILDWOOD CITY WATER DEPARTMENT	1.14	1.23	1.40	1.62	1.77	0.31	0.35	0.40	0.44
NJ0516001	WOODBINE MUA	0.21	0.19	0.20	0.22	0.23	0.66	0.71	0.77	0.81
NJ0516003	CAROL LYNN RESORTS, INC.	0.09	0.09	0.09	0.09	0.09	10.90	10.96	11.04	11.10
NJ0601001	BRIDGETON CITY WATER DEPT	1.12	0.56	0.71	0.91	1.04	0.19	0.24	0.31	0.36
NJ0604001	BAYVIEW WATER SYSTEM	0.06	0.05	0.06	0.06	0.06	2.70	2.76	2.85	2.91
NJ0605001	FAIRTON OAKS M H COMMUNITY	0.08	0.07	0.07	0.08	0.08	5.59	5.66	5.75	5.81
NJ0605002	TIPS TRAILER PARK & SALE	0.05	0.04	0.04	0.05	0.05	1.21	1.27	1.34	1.40
NJ0605004	FAIRTON FEDERAL CORRECTIONAL INSTITUTION	0.16	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0607001	HOPEWELL PLACE SENIOR APTS	0.08	0.07	0.07	0.07	0.07	6.03	6.11	6.23	6.30
NJ0609001	NJ STATE PRISON BAYSIDE	-0.01	-1.88	-1.77	-1.62	-1.52	-2.52	-2.37	-2.17	-2.03
NJ0610001	MILLVILLE WATER DEPARTMENT	1.46	1.45	1.60	1.81	1.94	0.41	0.45	0.51	0.55
NJ0610002	COUNTRY MEADOWS RENTS AND SALES MHP LLC	0.07	0.07	0.07	0.07	0.07	3.05	3.10	3.16	3.20
NJ0612001	BAYSHORE MOBILE HOME PARK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0613004	UPPER DEERFIELD TWP WATER DEPT	0.50	0.47	0.50	0.53	0.55	0.85	0.90	0.96	1.00
NJ0614002	PARKWOOD BRANCH TERRACES	0.01	-0.02	-0.01	-0.01	-0.01	-0.26	-0.20	-0.13	-0.07
NJ0614003	VINELAND WATER & SEWER UTILITY	2.00	1.57	1.90	2.36	2.66	0.21	0.25	0.32	0.36

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NJ0614004	CHAPMAN MANUFACTURED HOUSING	0.08	0.07	0.07	0.07	0.08	4.11	4.17	4.24	4.30
NJ0614005	UNITED MOBILE HOMES OF VINELAND	0.01	-0.07	-0.06	-0.05	-0.04	-0.59	-0.51	-0.42	-0.35
NJ0701001	BELLEVILLE WATER DEPT	1.06	0.56	0.76	0.99	1.17	0.15	0.20	0.26	0.31
NJ0702001	BLOOMFIELD WATER DEPARTMENT	1.78	1.55	1.80	2.10	2.33	0.29	0.34	0.40	0.44
NJ0703001	CALDWELL WATER DEPT	0.17	0.17	0.21	0.26	0.29	0.21	0.26	0.31	0.35
NJ0704001	CEDAR GROVE WATER DEPT	0.07	-0.11	-0.03	0.05	0.12	-0.08	-0.02	0.04	0.08
NJ0705001	EAST ORANGE WATER COMMISSION	6.95	6.76	7.10	7.50	7.81	0.93	0.98	1.03	1.08
NJ0706001	ESSEX FELLS WATER DEPT	0.21	0.72	0.84	0.99	1.10	0.22	0.26	0.31	0.34
NJ0706002	ESSEX FELLS WATER HILLTOP SYSTEM	0.14	0.13	0.13	0.14	0.14	1.29	1.35	1.41	1.46
NJ0707001	FAIRFIELD WATER DEPT	0.40	0.28	0.34	0.41	0.46	0.24	0.29	0.35	0.39
NJ0708001	GLEN RIDGE WATER DEPT	-0.64	-0.75	-0.70	-0.65	-0.61	-0.82	-0.77	-0.71	-0.66
NJ0710001	LIVINGSTON TWP DIV OF WATER	0.29	-0.07	0.14	0.38	0.56	-0.02	0.03	0.09	0.14
NJ0712001	NJ AMERICAN WATER - PASSAIC BASIN	11.49	12.54	14.34	16.37	17.98	0.31	0.36	0.41	0.45
NJ0713001	MONTCLAIR WATER BUREAU	1.52	1.16	1.46	1.81	2.08	0.19	0.24	0.30	0.34
NJ0714001	NEWARK WATER DEPARTMENT	27.08	41.53	44.33	45.51	48.13	0.55	0.59	0.60	0.64
NJ0715001	NORTH CALDWELL WATER DEP	0.40	0.35	0.39	0.45	0.49	0.35	0.40	0.46	0.50
NJ0715002	NORTH CALDWELL - HILLTOP	0.09	0.08	0.09	0.09	0.10	0.84	0.89	0.95	1.00
NJ0716001	NUTLEY WATER DEPT	-0.84	-1.03	-0.86	-0.67	-0.51	-0.30	-0.25	-0.19	-0.15
NJ0717001	ORANGE WATER DEPT	-0.30	0.29	0.42	0.58	0.70	0.08	0.12	0.17	0.20
NJ0718001	ROSELAND WATER DEPT	0.07	0.01	0.05	0.10	0.13	0.02	0.07	0.12	0.17
NJ0719001	SOUTH ORANGE WATER DEPARTMENT	0.27	0.24	0.35	0.47	0.57	0.10	0.15	0.20	0.25
NJ0720001	VERONA WATER DEPARTMENT	1.18	1.07	1.15	1.24	1.30	0.69	0.74	0.80	0.84
NJ0721001	WEST CALDWELL WATER DEPARTMENT	0.07	0.37	0.42	0.47	0.52	0.27	0.30	0.35	0.38
NJ0801001	CLAYTON WATER DEPARTMENT	0.20	0.13	0.16	0.20	0.23	0.20	0.24	0.31	0.35

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NJ0802001	DEPTFORD TWP MUA	0.46	0.62	0.72	0.86	0.96	0.23	0.27	0.33	0.36
NJ0803001	EAST GREENWICH TWP WATER DEPT	0.20	0.23	0.27	0.32	0.36	0.23	0.27	0.33	0.37
NJ0804001	LAUX LAKEVIEW MOBILE H P INC	0.05	0.04	0.04	0.04	0.05	1.12	1.18	1.26	1.31
NJ0804308	OLDMANS CREEK CAMPGROUND	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0805001	IONA TRAILER PARK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0805002	MALAGA MOBILE LLC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0805003	MALAGA VILLA APARTMENTS	0.09	0.09	0.09	0.09	0.09	16.71	16.76	16.81	16.85
NJ0805433	HOLLY GREEN CAMPGROUND	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ0806001	GLASSBORO WATER DEPARTMENT	0.78	0.95	1.05	1.18	1.27	0.38	0.42	0.48	0.51
NJ0807001	GREENWICH TWP W DEPT	0.31	0.31	0.34	0.38	0.40	0.48	0.52	0.58	0.62
NJ0808001	NJ AMERICAN WATER - HARRISON	0.36	0.02	0.08	0.16	0.22	0.02	0.08	0.15	0.20
NJ0809001	NJ AMERICAN WATER - BRIDGEPORT	0.20	0.16	0.16	0.17	0.18	1.96	2.02	2.11	2.16
NJ0809002	NJ AMERICAN WATER - LOGAN	0.37	0.47	0.53	0.61	0.66	0.30	0.34	0.39	0.42
NJ0810004	MANTUA TOWNSHIP MUA	0.39	0.23	0.28	0.36	0.40	0.21	0.26	0.33	0.37
NJ0810005	MANOR WATER ASSOCIATIONS	0.09	0.08	0.08	0.08	0.09	13.57	13.62	13.69	13.73
NJ0811002	MONROE TWP MUA	0.07	-0.46	-0.33	-0.15	-0.03	-0.18	-0.13	-0.06	-0.01
NJ0812001	NATIONAL PARK WATER DEPARTMENT	0.07	0.09	0.10	0.11	0.11	0.44	0.48	0.53	0.56
NJ0813001	NEWFIELD WATER DEPARTMENT	0.35	0.36	0.37	0.37	0.38	2.45	2.49	2.54	2.58
NJ0814001	PAULSBORO WATER DEPARTMENT	0.32	0.47	0.49	0.52	0.53	0.75	0.78	0.83	0.86
NJ0815001	PITMAN WATER DEPARTMENT	0.22	0.16	0.19	0.22	0.25	0.28	0.33	0.39	0.43
NJ0816001	HARRISONVILLE MOBILE HOME PARK	0.01	0.00	0.01	0.01	0.01	0.08	0.13	0.19	0.23
NJ0817001	SWEDESBORO WATER DEPARTMENT	0.16	0.15	0.16	0.17	0.18	0.67	0.72	0.78	0.82
NJ0818004	WASHINGTON TOWNSHIP MUA	1.68	1.18	1.38	1.64	1.82	0.29	0.34	0.40	0.44
NJ0819001	WENONAH WATER DEPARTMENT	0.04	0.04	0.05	0.06	0.06	0.23	0.27	0.33	0.37

Draft for Public Comment

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		Deficit/ Surplus								
NJ0820001	WEST DEPTFORD TWP WATER DEPT	0.52	0.09	0.21	0.38	0.49	0.03	0.08	0.15	0.20
NJ0821001	WESTVILLE WATER DEPARTMENT	0.03	0.05	0.07	0.10	0.12	0.11	0.15	0.20	0.24
NJ0822001	WOODBURY CITY W DEPT	0.30	0.31	0.36	0.42	0.46	0.28	0.32	0.38	0.42
NJ0823001	WOODBURY HEIGHTS W UTILITY	0.16	0.16	0.17	0.18	0.19	0.75	0.79	0.85	0.89
NJ0824001	AQUA NJ - WOOLWICH	0.54	0.07	0.12	0.18	0.22	0.12	0.19	0.30	0.36
NJ0901001	BAYONNE MUA	0.41	0.02	0.45	0.95	1.34	0.00	0.05	0.11	0.15
NJ0902001	EAST NEWARK W DEPT	-0.34	-0.43	-0.41	-0.39	-0.37	-1.56	-1.49	-1.42	-1.37
NJ0904001	HARRISON WATER DEPARTMENT	0.03	-0.99	-0.87	-0.73	-0.62	-0.61	-0.54	-0.45	-0.38
NJ0905001	HOBOKEN WATER DEPT	0.71	0.87	1.08	1.32	1.51	0.19	0.23	0.28	0.32
NJ0906001	JERSEY CITY MUA	7.19	-6.24	-3.53	-0.35	2.08	-0.14	-0.08	-0.01	0.05
NJ0907001	KEARNY WATER DEPARTMENT	6.25	5.49	5.79	6.14	6.41	0.95	1.01	1.07	1.11
NJ1001301	VALLEYVIEW HEALTHCARE & REHABILITATION CENTER	0.08	0.07	0.07	0.08	0.08	1.01	1.06	1.12	1.17
NJ1004001	AQUA NJ INC - CALIFON	0.32	0.43	0.51	0.61	0.68	0.23	0.27	0.32	0.36
NJ1005001	CLINTON W DEPT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1006300	TEEN CHALLENGE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1006302	ROLLING HILLS CARE CENTER	0.04	0.04	0.04	0.04	0.04	0.75	0.80	0.86	0.91
NJ1007001	DELAWARE TOWNSHIP MUA	0.06	0.06	0.06	0.06	0.06	3.17	3.21	3.27	3.31
NJ1007002	ROSEMONT WATER DEPARTMENT	0.20	0.20	0.22	0.25	0.28	0.35	0.40	0.46	0.50
NJ1009001	FLEMINGTON WATER DEPARTMENT	0.12	0.12	0.13	0.13	0.14	1.15	1.20	1.25	1.29
NJ1011001	NJ AMERICAN WATER - FRENCHTOWN	0.06	0.06	0.06	0.07	0.07	0.67	0.72	0.77	0.82
NJ1012001	GLEN GARDNER W DEPT	0.03	0.07	0.07	0.08	0.08	0.56	0.59	0.63	0.66
NJ1013001	HAMPTON BOROUGH WATER DEPARTMENT	-0.05	0.24	0.25	0.26	0.27	0.44	0.46	0.48	0.50
NJ1014001	HIGH BRIDGE W DEPT	0.03	0.02	0.03	0.03	0.03	0.44	0.49	0.55	0.60
NJ1015003	AQUA NJ INC - RIEGEL RIDGE	0.00	0.00	0.00	0.00	0.00	0.13	0.18	0.23	0.28

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NJ1015004	AQUA NJ - FOX HILL	0.37	0.43	0.44	0.46	0.47	1.48	1.52	1.56	1.60
NJ1017001	SUEZ WATER NEW JERSEY LAMBERTVILLE	0.05	0.05	0.05	0.05	0.05	2.27	2.32	2.38	2.43
NJ1019001	AQUA NJ INC - BUNNVALE	0.03	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1019002	HAGEDORN PSYCIATRIC HOSPITAL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1019003	CAMELOT AT SPRUCE RIDGE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1019301	HUNTERDON HILL RCF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1019311	LITTLE BROOK NURSING HOM	0.11	0.09	0.10	0.11	0.11	0.72	0.77	0.83	0.88
NJ1020001	MILFORD W DEPT	0.04	0.04	0.04	0.04	0.04	1.13	1.18	1.23	1.27
NJ1021363	HUNTERDON CARE CENTER	0.04	0.03	0.04	0.04	0.05	0.29	0.34	0.40	0.45
NJ1023001	STOCKTON WATER DEPARTMENT	0.07	0.07	0.07	0.07	0.07	3.84	3.90	3.96	4.01
NJ1024001	NJ AMERICAN WATER - OLDWICK	-0.01	0.14	0.15	0.15	0.16	0.59	0.61	0.63	0.64
NJ1025001	EDNA MAHAN CORRECTIONAL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1025313	COUNTRY ARCH CARE CENTER	0.02	0.02	0.02	0.02	0.02	0.66	0.72	0.80	0.85
NJ1101002	EAST WINDSOR MUA	0.87	0.99	1.10	1.25	1.34	0.37	0.41	0.47	0.50
NJ1103001	AQUA NJ - HAMILTON SQUARE	1.64	2.11	2.27	2.46	2.61	0.53	0.57	0.62	0.65
NJ1104001	HIGHTSTOWN WATER DEPARTMENT	0.35	0.31	0.34	0.37	0.40	0.51	0.56	0.62	0.66
NJ1105001	HOPEWELL BORO W DEPT	0.06	0.06	0.07	0.08	0.09	0.33	0.37	0.43	0.47
NJ1106001	HOPEWELL TOWNSHIP WATER & SEWER	0.01	0.00	0.01	0.01	0.01	0.03	0.08	0.14	0.18
NJ1106002	MERCER COUNTY CORRECTIONAL CEN	-0.04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1107001	LAWRENCEVILLE SCHOOL	0.05	0.02	0.02	0.03	0.03	0.18	0.24	0.31	0.37
NJ1107002	AQUA NJ - LAWRENCE	0.06	-0.19	-0.14	-0.09	-0.05	-0.27	-0.20	-0.13	-0.08
NJ1108001	PENNINGTON W DEPT	0.12	0.12	0.13	0.15	0.16	0.54	0.58	0.63	0.67
NJ1111001	TRENTON WATER WORKS	12.55	13.88	15.05	16.43	17.49	0.52	0.56	0.61	0.65
NJ1204001	EAST BRUNSWICK TWP WATER & SEWER UTILITY	0.71	-0.49	-0.14	0.32	0.63	-0.07	-0.02	0.05	0.09

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NJ1205001	NJ AMERICAN WATER - EDISON SYSTEM	7.23	7.44	7.72	8.05	8.31	1.18	1.22	1.28	1.32
NJ1206001	HELMETTA WATER DEPT	0.05	0.06	0.06	0.07	0.08	0.35	0.39	0.45	0.49
NJ1207001	HIGHLAND PARK W DEPT	0.20	0.19	0.27	0.35	0.42	0.12	0.17	0.22	0.27
NJ1209002	OLD BRIDGE MUA	1.04	-0.18	0.15	0.60	0.90	-0.03	0.02	0.09	0.14
NJ1212001	MILLTOWN W DEPT	0.26	0.23	0.26	0.30	0.32	0.38	0.42	0.48	0.52
NJ1213002	MONROE TOWNSHIP UTILITY DEPARTMENT	0.20	-0.53	-0.29	0.03	0.25	-0.11	-0.06	0.01	0.05
NJ1213321	JAMESBURG MANOR	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1214001	NEW BRUNSWICK WATER DEPARTMENT	3.54	1.57	2.32	3.19	3.86	0.11	0.16	0.22	0.27
NJ1215001	NORTH BRUNSWICK WATER DEPARTMENT	1.26	0.73	1.00	1.32	1.57	0.13	0.19	0.24	0.29
NJ1216001	PERTH AMBOY WATER DEPARTMENT	0.63	1.87	2.09	2.34	2.54	0.31	0.35	0.39	0.42
NJ1219001	SAYREVILLE W DEPT	10.34	11.22	11.58	11.74	12.08	1.21	1.25	1.27	1.30
NJ1221004	SOUTH BRUNSWICK TOWNSHIP WATER DIVISION	2.33	0.63	0.97	1.37	1.67	0.11	0.17	0.24	0.30
NJ1223001	SOUTH RIVER W DEPT	-0.61	-0.68	-0.62	-0.54	-0.49	-0.54	-0.49	-0.43	-0.39
NJ1224001	SPOTSWOOD W DEPT	0.17	0.12	0.15	0.19	0.21	0.18	0.23	0.29	0.33
NJ1225001	MIDDLESEX WATER COMPANY	8.21	1.47	3.81	6.57	8.67	0.03	0.09	0.15	0.20
NJ1302001	ALLENTOWN WATER DEPT	0.09	0.09	0.09	0.10	0.11	0.52	0.56	0.62	0.65
NJ1304001	ATLANTIC HIGHLANDS WATER	0.14	0.11	0.13	0.15	0.17	0.28	0.32	0.38	0.43
NJ1305001	AVON BY THE SEA WATER DE	0.00	0.00	0.01	0.03	0.04	0.01	0.05	0.11	0.14
NJ1306001	BELMAR WATER DEPT	-0.03	-0.07	-0.03	0.01	0.05	-0.09	-0.04	0.02	0.06
NJ1308001	BRIELLE WATER DEPT	0.01	0.01	0.03	0.07	0.09	0.01	0.06	0.11	0.15
NJ1309001	US NAVAL WEAPONS STATION	-0.36	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1309002	S B WATER COMPANY	-0.14	-0.15	-0.15	-0.14	-0.14	-2.11	-2.06	-2.00	-1.95
NJ1309415	BRANDYWINE ASSISTED LIVING AT COLTS NECK	0.08	0.08	0.08	0.08	0.08	10.06	10.06	10.06	10.06
NJ1312001	ENGLISHTOWN WATER DEPT	-0.01	0.02	0.03	0.04	0.05	0.09	0.13	0.18	0.21

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			NCNWL	NCOWL	CNWL	COWL	NCNWL	NCOWL	CNWL	COWL
		Deficit/ Surplus								
NJ1314001	FARMINGDALE WATER DEPT	0.05	0.06	0.07	0.08	0.08	0.43	0.47	0.53	0.56
NJ1315001	FREEHOLD BOROUGH WATER DEPARTMENT	0.46	0.41	0.46	0.53	0.58	0.33	0.37	0.43	0.47
NJ1316001	FREEHOLD TWP WATER DEPT	1.03	0.48	0.68	0.96	1.14	0.11	0.16	0.23	0.27
NJ1319003	ANGLE INN MOTOR COURT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NJ1319007	PARKWAY WATER COMPANY	0.64	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1319008	WINDING BROOK MHP SYS 1	0.08	0.08	0.08	0.08	0.08	8.56	8.60	8.66	8.70
NJ1319009	WINDING BROOK MHP SYSTEM 2	0.08	0.07	0.08	0.08	0.08	4.45	4.49	4.55	4.59
NJ1319010	GREEN ACRES NJ MHC LLC	0.06	0.06	0.06	0.06	0.07	2.50	2.54	2.59	2.62
NJ1321001	KEANSBURG WATER & SEWER DEPT.	0.27	0.20	0.23	0.28	0.32	0.25	0.29	0.36	0.40
NJ1322001	KEYPORT WATER DEPT	0.25	0.22	0.24	0.28	0.30	0.37	0.41	0.47	0.51
NJ1326001	GORDONS CORNER WATER CO	0.16	-0.14	0.08	0.39	0.59	-0.03	0.02	0.08	0.12
NJ1326002	SUEZ WATER MANALAPAN KNOB HILL	-1.41	-1.33	-1.29	-1.25	-1.22	-1.57	-1.53	-1.48	-1.44
NJ1326004	SUEZ WATER MATCHAPONIX	1.91	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1326005	SUEZ WATER MANALAPAN MILLHURST	0.21	0.21	0.21	0.21	0.21	15.94	15.98	16.03	16.07
NJ1326007	SUEZ WATER MANALAPAN TRACEY STATION	0.17	0.17	0.17	0.18	0.18	3.56	3.60	3.65	3.69
NJ1326321	MARIANNE MANOR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NJ1327001	MANASQUAN WATER DEPARTMENT	0.15	0.15	0.17	0.21	0.23	0.25	0.29	0.35	0.39
NJ1328002	MARLBORO TOWNSHIP WATER UTILITY DIVISION	1.36	1.51	1.74	2.04	2.24	0.28	0.32	0.38	0.41
NJ1328003	MARLBORO STATE HOSPITAL	0.28	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1329001	MATAWAN BOROUGH WATER DE	-0.02	-0.06	-0.02	0.03	0.06	-0.07	-0.03	0.03	0.07
NJ1330002	ABERDEEN - CLIFFWOOD/CLIFFWOOD BEACH	1.58	1.71	1.74	1.77	1.80	2.40	2.43	2.48	2.51
NJ1330003	ABERDEEN- HIGH SCHOOL/OAKSHADE AREA	0.08	0.10	0.11	0.11	0.12	0.86	0.89	0.94	0.97
NJ1330004	ABERDEEN - FRENEAU	-0.02	-0.03	-0.03	-0.03	-0.03	-1.72	-1.66	-1.58	-1.53
NJ1331001	GATEWAY NATIONAL REC ARE	0.02	-0.04	-0.03	-0.02	-0.02	-0.36	-0.29	-0.20	-0.14

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NJ1332314	MILLSTONE MANOR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NJ1339001	SHORELANDS WATER CO INC	0.30	0.75	0.94	1.20	1.37	0.15	0.19	0.24	0.28
NJ1340001	RED BANK WATER DEPT	0.16	0.07	0.15	0.25	0.31	0.05	0.09	0.15	0.19
NJ1341001	ROOSEVELT WATER DEPT	0.05	0.03	0.04	0.04	0.05	0.36	0.42	0.49	0.53
NJ1344001	SEA GIRT WATER DEPT	0.15	0.13	0.14	0.16	0.17	0.51	0.55	0.61	0.65
NJ1345001	NJ AMERICAN WATER - COASTAL NORTH	9.25	12.83	14.69	17.21	18.89	0.27	0.31	0.36	0.40
NJ1347001	LAKE COMO WATER DEPT	-0.11	-0.13	-0.12	-0.11	-0.10	-0.68	-0.63	-0.57	-0.52
NJ1348001	SPRING LAKE WATER DEPARTMENT	0.12	0.08	0.10	0.13	0.15	0.17	0.22	0.28	0.32
NJ1349001	BOROUGH OF SPRINGLAKE HEIGHTS	0.23	0.23	0.25	0.27	0.29	0.50	0.54	0.60	0.64
NJ1350001	NJ AMERICAN WATER - UNION BEACH	-0.28	-0.35	-0.32	-0.29	-0.27	-0.64	-0.59	-0.54	-0.49
NJ1352003	WALL TWP WATER DEPT	0.41	0.26	0.37	0.52	0.62	0.11	0.15	0.22	0.26
NJ1401001	BOONTON WATER DEPT	101.65	101.65	101.65	101.65	101.65	4.02	4.02	4.02	4.02
NJ1401002	BOONTON TWP WATER DEPT	0.42	0.39	0.42	0.47	0.51	0.47	0.52	0.57	0.62
NJ1403001	BUTLER WATER DEPT	0.20	0.19	0.20	0.20	0.20	2.96	3.01	3.07	3.12
NJ1404001	CHATHAM WATER DEPT	1.83	1.80	1.87	1.94	2.00	1.36	1.41	1.46	1.51
NJ1406002	WINDY ACRES MOBILE HOME	0.30	0.27	0.31	0.36	0.40	0.29	0.34	0.39	0.43
NJ1407001	AWM FOUR SEASONS AT CHESTER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1408001	DENVILLE TWP WATER DEPT	-0.01	-0.02	-0.01	-0.01	-0.01	-0.41	-0.36	-0.29	-0.24
NJ1409001	DOVER WATER COMMISSION	0.30	0.42	0.51	0.63	0.71	0.19	0.23	0.28	0.32
NJ1410001	EAST HANOVER TWP WATER DEPT	0.08	0.56	0.68	0.82	0.92	0.19	0.22	0.27	0.30
NJ1411001	FLORHAM PARK WATER DEPT	0.17	-0.25	-0.14	-0.01	0.08	-0.13	-0.07	-0.01	0.04
NJ1413001	LAKESHORE COMPANY	-0.22	-0.13	-0.07	0.00	0.06	-0.09	-0.05	0.00	0.04
NJ1414003	JEFFERSON TWP W U MILTON SYSTEM	0.05	0.05	0.05	0.05	0.05	1.15	1.20	1.25	1.30
NJ1414006	LOZIERS TRAILER PARK	0.13	0.15	0.16	0.17	0.19	0.57	0.61	0.66	0.70

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NJ1414008	OAK RIDGE MOBILE HOME PARK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1414011	JEFFERSON TWP WATER UTILITY LAKE HOPATCONG	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1414013	SUN VALLEY PARK	0.34	0.22	0.26	0.30	0.33	0.34	0.40	0.46	0.51
NJ1414014	SANDY POINT MOBILE HOME	0.07	0.07	0.07	0.07	0.07	3.05	3.05	3.05	3.05
NJ1414016	JEFFERSON TWP W U VASSAR ROAD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1415001	FAYSON LAKES WATER COMPANY INC	0.00	0.00	0.00	0.01	0.01	0.63	0.66	0.71	0.74
NJ1415002	KINNELON WATER DEPT	0.01	-0.03	-0.02	0.00	0.01	-0.12	-0.07	-0.01	0.04
NJ1416001	BOROUGH OF LINCOLN PARK WATER DEPT	0.46	0.46	0.47	0.48	0.48	2.37	2.41	2.47	2.51
NJ1416004	BOROUGH OF LINCOLN PARK JACKSONVILLE SYST	0.14	0.12	0.18	0.26	0.32	0.08	0.13	0.18	0.23
NJ1417001	MADISON WATER DEPT	-0.06	-0.06	-0.06	-0.05	-0.05	-0.97	-0.93	-0.88	-0.84
NJ1418002	SISTERS OF CHRISTIAN CHARITY	0.30	0.20	0.30	0.42	0.51	0.09	0.14	0.20	0.24
NJ1419001	ROXITICUS WATER COMPANY INC.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1420001	MINE HILL TWP WATER DEPT	0.22	0.24	0.25	0.26	0.27	1.07	1.12	1.17	1.20
NJ1421003	MONTVILLE TWP MUA	0.44	0.60	0.70	0.83	0.93	0.24	0.28	0.33	0.37
NJ1421305	ST ALBERTS RESIDENTIAL HEALTH CENTER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1422001	SISTERS OF CHARITY OF SE	0.03	0.03	0.03	0.04	0.04	0.61	0.66	0.71	0.74
NJ1424001	SOUTHEAST MORRIS COUNTY MUA	4.24	5.41	5.79	6.22	6.56	0.58	0.63	0.67	0.71
NJ1425001	MOUNTAIN LAKES WATER DEP	0.05	0.02	0.05	0.08	0.11	0.04	0.09	0.14	0.19
NJ1426002	MOUNT ARLINGTON DPW KADEL SYS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NJ1426004	SUEZ WATER NEW JERSEY ARLINGTON HILLS	0.07	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1426005	MOUNT ARLINGTON BORO DPW MAIN	0.02	0.04	0.05	0.06	0.07	0.15	0.19	0.24	0.28
NJ1427001	MT OLIVE VILLAGES WATER	0.12	0.21	0.22	0.23	0.23	0.81	0.84	0.88	0.90
NJ1427002	MOUNT OLIVE TWP - GOLDMINE SYSTEM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1427005	MOUNT OLIVE TWP - FLANDERS	0.07	0.02	0.06	0.10	0.13	0.03	0.08	0.14	0.18

Draft for Public Comment

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NJ1427006	MOUNT OLIVE TWP - SAND	0.06	0.05	0.05	0.05	0.06	0.77	0.82	0.89	0.94
NJ1427007	MOUNT OLIVE TWP - VILLAGE	0.04	0.07	0.08	0.08	0.09	0.48	0.51	0.56	0.59
NJ1427008	MOUNT OLIVE TWP - PINECREST	0.02	0.01	0.01	0.02	0.02	0.21	0.26	0.33	0.38
NJ1427009	NJ AMERICAN WATER - MOUNT OLIVE - WEST JERSEY	0.04	0.03	0.03	0.03	0.04	0.60	0.65	0.71	0.76
NJ1427010	NJ VASA HOME WATER SYS	0.03	0.02	0.03	0.03	0.03	1.94	2.01	2.08	2.14
NJ1427012	MOUNT OLIVE TWP - LYNWOOD	0.01	0.01	0.01	0.01	0.01	3.44	3.49	3.54	3.59
NJ1427014	MOUNT OLIVE TWP - CARLTON HILLS	0.01	0.01	0.01	0.02	0.02	0.30	0.35	0.40	0.44
NJ1427015	MOUNT OLIVE TWP - TINC FARM	0.03	0.02	0.03	0.03	0.03	0.43	0.48	0.55	0.60
NJ1427016	AWM COUNTRY OAKS	0.02	0.02	0.02	0.02	0.02	0.58	0.58	0.58	0.58
NJ1427017	NJ AMERICAN WATER - ITC	0.30	0.29	0.29	0.30	0.31	1.63	1.68	1.74	1.78
NJ1427018	MORRIS CHASE/MORRIS HUNT PCWS	0.04	0.04	0.04	0.05	0.05	0.41	0.46	0.52	0.56
NJ1428001	NETCONG WATER DEPT	0.17	0.17	0.19	0.20	0.21	0.58	0.62	0.68	0.72
NJ1429001	PARSIPPANY-TROY HILLS WATER DEPARTMENT	1.49	1.89	2.18	2.51	2.77	0.29	0.33	0.38	0.42
NJ1431001	PEQUANNOCK TWP WATER DEPARTMENT	0.95	0.64	0.73	0.84	0.92	0.40	0.45	0.52	0.57
NJ1431002	PEQUANNOCK TWP WD-CEDAR CREST	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1432001	MORRIS COUNTY MUA	1.87	1.87	2.08	2.32	2.51	0.41	0.46	0.51	0.55
NJ1432003	RANDOLPH TWP PUBLIC WORKS DEPT	0.41	0.29	0.37	0.47	0.54	0.18	0.22	0.28	0.33
NJ1433001	RIVERDALE BORO WATER DEP	0.13	0.09	0.12	0.15	0.18	0.15	0.19	0.25	0.30
NJ1434001	ROCKAWAY BORO WATER DEPT	0.26	0.27	0.32	0.37	0.41	0.28	0.32	0.38	0.42
NJ1435001	HOFFMAN HOMES COMMUNITY LLC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1435002	ROCKAWAY TWP WATER DEPT	0.12	-0.16	-0.08	0.02	0.10	-0.11	-0.05	0.01	0.06
NJ1435003	AWO&M - PICATINNY ARSENAL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1436002	ROXBURY WATER CO	0.29	0.13	0.18	0.24	0.29	0.14	0.19	0.26	0.30
NJ1436003	ROXBURY TWP W DEPT-SHORE	0.26	0.25	0.26	0.28	0.30	0.74	0.79	0.84	0.89

Draft for Public Comment

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NJ1436004	ROXBURY TWP W DEPT-SKY V	0.16	0.17	0.19	0.21	0.23	0.42	0.46	0.52	0.56
NJ1438001	AQUA NJ CLIFFSIDE PARK	0.05	0.05	0.05	0.05	0.05	9.06	9.11	9.17	9.21
NJ1438003	WASHINGTON TWP MUA-HAGER	0.04	0.04	0.04	0.04	0.04	7.69	7.73	7.78	7.82
NJ1438004	WASHINGTON TWP MUA-SCHOOLEYS MOUNTAIN	0.05	0.04	0.06	0.07	0.09	0.13	0.18	0.23	0.27
NJ1438006	SHERWOOD VILLAGE	0.02	0.08	0.10	0.13	0.15	0.14	0.18	0.23	0.27
NJ1439001	WHARTON WATER DEPT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1501001	BARNEGAT LIGHT WATER DEP	-0.27	-0.19	-0.12	-0.04	0.02	-0.12	-0.08	-0.03	0.01
NJ1503001	BEACH HAVEN WATER DEPT	-0.20	-0.25	-0.23	-0.20	-0.18	-0.56	-0.51	-0.45	-0.40
NJ1504001	BEACHWOOD WATER DEPT	0.31	0.22	0.24	0.27	0.29	0.52	0.58	0.65	0.69
NJ1505002	AQUA NJ - EASTERN DIVISION	0.09	0.04	0.08	0.13	0.17	0.04	0.09	0.15	0.19
NJ1505003	SHORE WATER COMPANY	0.38	0.44	0.47	0.52	0.55	0.52	0.56	0.62	0.65
NJ1505004	BERKELEY TWP MUA	0.08	-0.20	-0.18	-0.16	-0.14	-1.13	-1.02	-0.87	-0.77
NJ1506001	BRICK TOWNSHIP MUA	0.84	0.86	0.89	0.94	0.96	1.17	1.22	1.27	1.31
NJ1507005	SUEZ WATER TOMS RIVER INC	7.39	5.98	6.41	6.99	7.37	0.69	0.74	0.81	0.85
NJ1507007	NJ AMERICAN WATER - ORTLEY BEACH	7.13	5.30	5.84	6.57	7.05	0.49	0.54	0.61	0.65
NJ1507008	NJ AMERICAN WATER - PELICAN ISLAND	0.06	0.06	0.06	0.06	0.06	4.02	4.06	4.12	4.16
NJ1508001	EAGLESWOOD VILLAGE MHP	-0.16	-0.15	-0.13	-0.11	-0.09	-0.37	-0.33	-0.27	-0.24
NJ1509001	HARVEY CEDARS WATER DEPT	0.07	0.03	0.04	0.05	0.06	0.15	0.20	0.27	0.32
NJ1510001	ISLAND HEIGHTS WATER DEP	2.43	1.02	1.21	1.47	1.64	0.33	0.39	0.47	0.53
NJ1511001	JACKSON TWP MUA	0.04	0.01	0.01	0.02	0.02	0.33	0.40	0.50	0.57
NJ1511002	JACKSON ACRES MHP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NJ1511003	LAND O PINES MOBILE HOME PARK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NJ1511004	MAPLE GLEN MOBILE HOME PARK	0.07	0.06	0.07	0.07	0.07	2.97	3.02	3.09	3.14
NJ1511005	OAK TREE MOBILE HOME PARK	-0.16	-0.44	-0.42	-0.38	-0.35	-1.11	-1.04	-0.94	-0.88

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NJ1511007	SILVER PINE PARK LAND LLC	0.01	0.00	0.01	0.01	0.01	0.05	0.10	0.17	0.21
NJ1511008	SOUTH WIND MOBILE HOME V	0.05	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1511010	USDOD JOINT BASE MCGUIRE DIX LAKEHURST	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NJ1511011	ALL SEASONS MHP	0.09	0.08	0.08	0.08	0.09	7.41	7.46	7.53	7.57
NJ1511013	FOUNTAINHEAD PARKS INC	0.09	0.09	0.09	0.09	0.09	11.08	11.13	11.20	11.24
NJ1511016	MEADOWBROOK CO-OP INC	0.37	0.37	0.37	0.37	0.37	1.06	1.06	1.06	1.06
NJ1512001	LACEY TWP MUA	0.51	0.28	0.38	0.51	0.59	0.14	0.19	0.25	0.29
NJ1513001	LAKEHURST WATER DEPT	0.13	0.11	0.12	0.14	0.15	0.45	0.49	0.56	0.60
NJ1514002	LAKEWOOD TWP MUA	0.36	-0.43	-0.22	0.07	0.26	-0.10	-0.05	0.02	0.06
NJ1515001	LAVALLETTE WATER DEPT	0.14	0.10	0.12	0.14	0.15	0.30	0.34	0.41	0.45
NJ1516001	LITTLE EGG HARBOR TWP MU	0.96	0.43	0.51	0.62	0.70	0.30	0.36	0.44	0.49
NJ1517001	LONG BEACH TWP BRANT BEACH	0.17	0.20	0.24	0.30	0.33	0.22	0.26	0.31	0.35
NJ1517002	LONG BEACH TWP WATER DEPT HOLGATE	0.02	-0.04	-0.03	-0.01	0.00	-0.16	-0.11	-0.04	0.01
NJ1517003	LONG BEACH TWP NORTH BEACH	-0.24	-0.25	-0.24	-0.24	-0.23	-2.26	-2.21	-2.15	-2.11
NJ1517004	LONG BEACH TWP LOVE LADIES SOUTH	-0.42	-0.62	-0.61	-0.58	-0.57	-3.16	-3.08	-2.96	-2.88
NJ1517005	LONG BEACH TWP LOVE LADIES NORTH	-0.33	-0.49	-0.48	-0.46	-0.45	-3.13	-3.04	-2.92	-2.85
NJ1517006	LONG BEACH TWP HIGH BAR HARBOR	-0.28	-0.25	-0.25	-0.24	-0.24	-2.91	-2.88	-2.84	-2.82
NJ1518001	CEDAR GLEN HOMES INC	0.05	0.03	0.04	0.04	0.04	0.84	0.90	0.98	1.04
NJ1518002	CEDAR GLEN LAKES WATER C	0.04	0.02	0.03	0.04	0.05	0.16	0.21	0.27	0.32
NJ1518003	CEDAR GLEN WEST WATER CO	0.00	-0.02	-0.02	-0.01	0.00	-0.22	-0.17	-0.10	-0.05
NJ1518004	MANCHESTER TWP WATER - WESTERN	0.85	0.38	0.46	0.56	0.63	0.28	0.33	0.41	0.46
NJ1518005	MANCHESTER TWP WATER UTILITY - EASTERN	-0.37	-0.86	-0.74	-0.58	-0.47	-0.37	-0.32	-0.25	-0.20
NJ1518010	MANCHESTER VILLAGE	0.09	0.09	0.09	0.09	0.09	10.85	10.88	10.93	10.96
NJ1518011	MANCHESTER TWP WATER UTILITY LACEY ROAD	0.00	N/A	N/A	N/A	N/A	0.00	0.00	0.00	0.00

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NJ1518345	ARISTACARE AT MANCHESTER	0.38	-0.07	-0.01	0.08	0.14	-0.07	-0.01	0.08	0.13
NJ1520001	OCEAN TWP DEPT OF UTILITIES	0.02	-0.04	-0.02	-0.01	0.01	-0.14	-0.09	-0.02	0.02
NJ1521001	OCEAN GATE WATER DEPT	0.01	0.00	0.01	0.02	0.03	-0.02	0.03	0.09	0.13
NJ1522001	PINE BEACH WATER DEPT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NJ1523001	COLLIER MILLS MOBILE EST	0.03	0.02	0.02	0.02	0.03	0.62	0.68	0.77	0.82
NJ1523002	DEEP RUN ADULT VILLAGE	0.02	-0.02	-0.02	0.00	0.00	-0.16	-0.10	-0.02	0.03
NJ1523003	NJ AMERICAN WATER - NEW EGYPT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NJ1523004	OAK GROVE MHP	1.10	0.73	0.81	0.93	1.01	0.44	0.49	0.56	0.61
NJ1524001	POINT PLEASANT WATER DEPARTMENT	0.47	0.31	0.35	0.40	0.43	0.40	0.45	0.52	0.57
NJ1525001	POINT PLEASANT BEACH WATER DEPARTMENT	0.36	0.19	0.22	0.26	0.28	0.38	0.43	0.51	0.56
NJ1526001	SEASIDE HEIGHTS WATER DE	0.15	0.17	0.19	0.21	0.23	0.38	0.42	0.47	0.51
NJ1527001	SEASIDE PARK WATER DEPT	0.03	0.23	0.24	0.25	0.26	0.51	0.54	0.57	0.59
NJ1528001	SHIP BOTTOM WATER DEPART	-0.02	-0.02	-0.02	-0.02	-0.02	-3.18	-3.13	-3.06	-3.01
NJ1530003	STAFFORD TWP MUA CEDAR B	1.48	0.98	1.09	1.24	1.34	0.46	0.51	0.58	0.63
NJ1530004	STAFFORD TWP WATER - BEACH HAVEN WEST	0.14	0.09	0.10	0.11	0.11	0.74	0.80	0.88	0.94
NJ1530005	STAFFORD TWP MUA FAWN LA	0.42	0.37	0.39	0.42	0.44	0.85	0.90	0.96	1.00
NJ1530007	CEDAR RUN SENIOR CIT APT	0.18	0.13	0.14	0.16	0.18	0.40	0.45	0.52	0.57
NJ1531001	SURF CITY WATER DEPT	0.74	0.64	0.72	0.84	0.92	0.33	0.37	0.43	0.47
NJ1532002	TUCKERTON WATER & SEWER DEPT	0.04	-0.04	-0.04	-0.03	-0.02	-0.48	-0.39	-0.28	-0.21
NJ1533001	BARNEGAT TWP WATER & SEWER UTILITIES	0.05	-0.02	0.01	0.04	0.07	-0.04	0.02	0.08	0.12
NJ1533002	PINEWOOD ESTATES-BRIGHTN	0.21	0.11	0.17	0.24	0.30	0.08	0.13	0.19	0.24
NJ1601001	BLOOMINGDALE WATER DEPT	1.47	1.52	1.63	1.75	1.85	0.64	0.68	0.74	0.78
NJ1603001	MANCHESTER UTILITIES AUTHORITY	0.43	0.03	0.13	0.24	0.33	0.02	0.07	0.14	0.19
NJ1604001	HAWTHORNE WATER DEPARTMENT	5.37	-4.62	-0.14	3.98	8.07	-0.05	0.00	0.05	0.09

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NJ1605001	NJ AMERICAN WATER - LITTLE FALLS	0.06	0.07	0.07	0.07	0.07	4.55	4.55	4.55	4.55
NJ1605002	PASSAIC VALLEY WATER COMMISSION	0.25	-0.05	0.01	0.09	0.14	-0.05	0.01	0.08	0.14
NJ1606301	HOLLAND CHRISTIAN HOME	0.17	-0.06	-0.02	0.03	0.07	-0.09	-0.03	0.04	0.10
NJ1609001	POMPTON LAKES MUA	0.18	-0.06	0.04	0.16	0.25	-0.03	0.02	0.08	0.13
NJ1611002	RINGWOOD WATER DEPARTMENT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1612001	TOTOWA W DEPT	29.71	29.71	34.87	40.93	45.58	0.26	0.31	0.36	0.41
NJ1612301	LITTLE SISTERS OF THE POOR	0.99	0.84	0.89	0.95	0.99	0.88	0.93	1.00	1.05
NJ1613002	WANAQUE WATER DEPARTMENT	1.21	-0.28	0.13	0.61	0.98	-0.04	0.02	0.08	0.13
NJ1614001	WAYNE TOWNSHIP DIVISION OF WATER	-0.01	-0.01	-0.01	-0.01	-0.01	-0.80	-0.73	-0.66	-0.61
NJ1615001	WEST MILFORD TWP MUA - BIRCH HILL PARK	-0.01	-0.03	-0.03	-0.02	-0.02	-0.70	-0.64	-0.56	-0.49
NJ1615002	WEST MILFORD TWP MUA GREENBROOK ESTATES	-0.14	-0.17	-0.17	-0.16	-0.16	-1.73	-1.67	-1.60	-1.54
NJ1615003	PASSAIC VALLEY W C HIGH CREST	0.00	0.00	0.00	0.00	0.00	-0.37	-0.31	-0.24	-0.18
NJ1615006	WEST MILFORD TWP MUA PARKWAY	0.02	0.02	0.02	0.02	0.02	0.59	0.64	0.70	0.75
NJ1615008	PVWC-POSTBROOK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1615009	REFLECTION LAKES GARDEN APARTMENTS	-0.01	-0.06	-0.05	-0.05	-0.04	-1.07	-0.98	-0.88	-0.80
NJ1615012	WEST MILFORD TWP MUA AWOSTING	-0.05	-0.06	-0.06	-0.05	-0.05	-1.10	-1.05	-0.97	-0.92
NJ1615014	WEST MILFORD TWP MUA CRESCENT PARK	0.04	0.02	0.02	0.03	0.03	0.16	0.21	0.28	0.33
NJ1615016	WEST MILFORD TWP MUA OLDE MILFORD ESTATES	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1615017	WONDER LAKE PROPERTIES I	-0.02	-0.07	-0.06	-0.05	-0.05	-1.04	-0.96	-0.86	-0.79
NJ1615018	WEST MILFORD TWP BALD EAGLE VILLAGE	0.03	0.02	0.02	0.02	0.03	0.35	0.41	0.48	0.53
NJ1615020	SUEZ WATER NEW JERSEY WEST MILFORD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1615022	WOODLAND HEIGHTS HOMEOWNER ASSOC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1615340	MILFORD MANOR	0.13	0.19	0.23	0.29	0.33	0.18	0.22	0.27	0.31
NJ1616001	WOODLAND PARK WATER DEPARTMENT	0.10	0.11	0.11	0.12	0.12	0.89	0.93	0.98	1.01

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NJ1702001	ELMER BORO W DEPT	0.10	0.10	0.10	0.10	0.10	29.72	29.76	29.80	29.84
NJ1704001	LEISURE ARMS COMPLEX	0.08	0.08	0.09	0.09	0.09	8.19	8.23	8.27	8.30
NJ1706001	AUBURN VILLAGE WATER SUP	1.02	1.26	1.29	1.35	1.38	1.10	1.14	1.18	1.21
NJ1707001	NJ AMERICAN WATER - PENNS GROVE	0.20	0.42	0.46	0.52	0.55	0.36	0.40	0.44	0.47
NJ1708001	PENNSVILLE TWSP. WATER DEPARTMENT	0.02	0.01	0.02	0.02	0.03	0.18	0.23	0.29	0.34
NJ1710001	HARDING WOODS MHP	0.05	0.05	0.05	0.05	0.05	1.36	1.40	1.46	1.50
NJ1710002	HOLLY TREE ACRES SYSTEM 1	-0.08	-0.09	-0.09	-0.08	-0.08	-1.02	-0.98	-0.91	-0.87
NJ1710003	PICNIC GROVE MHC, LLC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1710006	VILLAGE I	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1710304	EAGLEVIEW HEALTH AND REHABILIATION	1.57	1.73	1.77	1.81	1.84	1.93	1.96	2.01	2.04
NJ1712001	SALEM WATER DEPARTMENT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1713001	HANDYS MOBILE PARK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1714001	COUNTRY CLUB ESTATES	0.07	0.07	0.07	0.07	0.07	4.40	4.44	4.50	4.53
NJ1714003	BANCROFT NEURO HEALTH CENTER	0.10	0.18	0.19	0.21	0.22	0.47	0.51	0.55	0.58
NJ1715001	WOODSTOWN WATER DEPARTMENT	0.06	0.06	0.06	0.07	0.07	3.85	3.89	3.94	3.98
NJ1803002	NJ AMERICAN WATER - TWIN LAKES	1.04	0.33	0.59	0.90	1.14	0.06	0.12	0.18	0.23
NJ1808001	FRANKLIN TOWNSHIP DEPT OF PUBLIC WORKS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1815300	MATHENY MEDICAL AND EDUCATION CENTER	0.01	0.00	0.01	0.01	0.02	0.05	0.10	0.16	0.20
NJ1817001	ROCKY HILL W DEPT	-0.02	-0.02	-0.02	-0.01	0.00	-0.18	-0.13	-0.08	-0.03
NJ1901001	ANDOVER BORO WATER DEPT	0.03	0.01	0.01	0.02	0.02	0.12	0.18	0.25	0.30
NJ1902003	LAKE LENAPE WATER CO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1902004	ANDOVER WATER CORP	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1902005	ASCOT PARK APTS	0.06	0.05	0.06	0.06	0.06	1.54	1.59	1.65	1.70
NJ1902007	ROLLING HILLS CONDOMINIUM ASSOCIATION	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

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NJ1902008	ANDOVER NURSING HOME	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1902009	ANDOVER INTERMEDIATE CARE CNTR	0.07	0.07	0.07	0.07	0.07	4.51	4.51	4.51	4.51
NJ1902346	WILLOW GLEN ACADEMY/ABBEY	0.08	0.07	0.08	0.08	0.08	0.84	0.89	0.94	0.99
NJ1903001	BRANCHVILLE W DEPT	0.04	0.04	0.04	0.05	0.05	0.40	0.44	0.50	0.54
NJ1904001	BROOKWOOD MUSCONETCONG RIVER POA	-0.01	0.00	0.00	0.00	0.00	-0.08	-0.04	0.01	0.05
NJ1904002	EAST BROOKWOOD ESTATES POA	0.04	0.00	0.01	0.02	0.02	0.04	0.10	0.17	0.23
NJ1904003	FOREST LAKES WATER COMPANY	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1904004	NORTH SHORE WATER ASSOCIATION	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1904006	STRAWBERRY POINT PROP OW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1904007	COLBY WATER CO	0.02	0.02	0.03	0.03	0.03	0.74	0.78	0.82	0.85
NJ1904009	AQUA NJ - BYRAM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1905002	CULVER LAKE WATER COMPANY	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1905004	SUSSEX CNTY HLTH-THE HOMESTED	0.02	0.00	0.01	0.01	0.01	0.09	0.15	0.22	0.28
NJ1906001	HILLSIDE ESTATES AT FRANKLIN	0.13	0.14	0.16	0.18	0.19	0.38	0.43	0.48	0.52
NJ1906002	FRANKLIN BOARD OF PUBLIC WORKS	0.09	0.09	0.09	0.09	0.09	9.97	10.02	10.08	10.13
NJ1907001	GREEN HILLS EST PROP OWN	0.05	0.05	0.05	0.05	0.05	2.02	2.07	2.13	2.18
NJ1907002	AQUA NJ - BEAR BROOK	0.07	0.07	0.08	0.08	0.08	3.16	3.20	3.25	3.29
NJ1908001	AQUA NJ - TRANQUILITY SPRINGS	0.16	0.17	0.18	0.20	0.21	0.61	0.66	0.71	0.75
NJ1909001	HAMBURG BOARD OF PUBLIC WORKS	0.08	0.07	0.07	0.07	0.07	4.49	4.55	4.62	4.68
NJ1910002	CARRIAGE MOBILE HOMES INC	0.06	0.05	0.05	0.06	0.06	1.51	1.58	1.65	1.70
NJ1910003	SUEZ WATER NEW JERSEY HAMPTON	-0.01	-0.03	-0.02	-0.01	-0.01	-0.20	-0.15	-0.09	-0.04
NJ1911001	AQUA NJ WALLKILL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1911002	LAKE STOCKHOLM INC	0.02	0.01	0.02	0.02	0.02	0.45	0.50	0.56	0.61
NJ1911003	LAKE TAMARACK W CO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

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NJ1911004	AQUA NJ - SUMMIT LAKE	0.05	0.04	0.04	0.04	0.05	0.55	0.60	0.66	0.71
NJ1911005	HARDYSTON TWP MUA	0.32	0.26	0.27	0.29	0.30	1.42	1.48	1.55	1.60
NJ1911006	HARDYSTON TWP MUA	0.11	0.14	0.16	0.18	0.19	0.35	0.39	0.44	0.48
NJ1912001	HOPATCONG WATER DEPT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1912300	LOCOR LAKEFRONT LODGING	0.13	0.11	0.11	0.12	0.12	1.24	1.30	1.37	1.43
NJ1914002	MONTAGUE WATER CO.	0.25	0.26	0.30	0.34	0.37	0.33	0.37	0.42	0.47
NJ1915001	NEWTON WATER & SEWER UTILITY	0.10	0.09	0.10	0.11	0.12	0.49	0.54	0.60	0.64
NJ1916001	OGDENSBURG W DEPT	0.06	0.10	0.10	0.11	0.11	0.75	0.79	0.82	0.85
NJ1918003	SPARTA TWP WATER UTILITY -- HIGHLANDS	0.36	0.24	0.32	0.41	0.47	0.16	0.21	0.27	0.31
NJ1918004	SPARTA TWP WATER UTILITY - LAKE MOHAWK	0.02	0.03	0.03	0.03	0.03	1.21	1.25	1.30	1.34
NJ1918013	SPARTA TWP WATER UTILITY - SUNSET	0.34	0.34	0.35	0.37	0.38	1.09	1.14	1.20	1.24
NJ1919001	STANHOPE W DEPT	0.04	0.06	0.06	0.07	0.07	0.43	0.47	0.52	0.56
NJ1920001	STILLWATER WATER DISTRICT 1	0.42	0.39	0.40	0.41	0.42	1.93	1.99	2.05	2.09
NJ1921001	SUSSEX WATER DEPT	0.00	0.00	0.00	0.00	0.00	-0.28	-0.23	-0.18	-0.14
NJ1922001	SUEZ WATER NEW JERSEY BARRY LAKES	0.01	0.01	0.01	0.01	0.01	3.70	3.76	3.83	3.88
NJ1922004	SUEZ WATER NEW JERSEY WOODRIDGE ESTATES	-0.02	-0.02	-0.02	-0.02	-0.02	-2.87	-2.83	-2.77	-2.73
NJ1922005	SUEZ WATER NEW JERSEY GRANDVIEW ESTATES	0.01	0.01	0.01	0.01	0.01	0.91	0.94	0.97	1.00
NJ1922006	SUEZ WATER NEW JERSEY SUSSEX HILLS	0.03	0.03	0.03	0.03	0.03	0.54	0.59	0.64	0.69
NJ1922008	AQUA NJ - VERNON	0.02	0.03	0.03	0.03	0.03	1.92	1.95	1.98	2.01
NJ1922010	VILLAGE OF LAKE GLENWOOD	0.03	0.03	0.03	0.03	0.03	2.26	2.31	2.36	2.40
NJ1922011	SUEZ WATER NEW JERSEY SUNSET RIDGE	-0.03	-0.03	-0.03	-0.03	-0.03	-2.78	-2.74	-2.68	-2.64
NJ1922012	SUEZ WATER NEW JERSEY LAKE CONWAY	-0.02	-0.02	-0.02	-0.02	-0.02	-3.38	-3.34	-3.28	-3.24
NJ1922013	SUEZ WATER NEW JERSEY DAVID CURTIS	0.00	0.00	0.00	0.00	0.00	-0.20	-0.16	-0.11	-0.07
NJ1922015	SUEZ WATER NEW JERSEY WALNUT HILLS	0.01	0.01	0.01	0.01	0.01	2.72	2.78	2.85	2.90

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NJ1922017	SUEZ WATER NEW JERSEY HIGHLAND LAKES	0.00	0.00	0.00	0.00	0.00	-0.43	-0.40	-0.36	-0.34
NJ1922021	SUEZ WATER NEW JERSEY PREDMORE ESTATES	-0.01	-0.01	-0.01	-0.01	-0.01	-0.92	-0.89	-0.85	-0.82
NJ1922022	SUEZ WATER NEW JERSEY SAMMIS ROAD	0.03	-0.01	0.01	0.04	0.06	-0.03	0.02	0.08	0.13
NJ1922026	SUEZ WATER NEW JERSEY VERNON VALLEY	0.03	0.03	0.03	0.03	0.04	3.13	3.18	3.24	3.28
NJ1922027	HIDDEN VILLAGE CONDO ASSOCIATION	0.09	0.09	0.09	0.09	0.09	8.72	8.77	8.82	8.86
NJ1924002	SIMMONS W CO	0.06	0.06	0.06	0.07	0.07	4.20	4.24	4.30	4.34
NJ1924003	REGENCY APARTMENTS LLC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1924004	SUEZ WATER NEW JERSEY WOODBRIDGE ESTATES	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ1924006	TOWN CENTER AT WANTAGE	7.54	5.23	6.01	6.94	7.64	0.35	0.41	0.47	0.52
NJ2004001	LIBERTY WATER CO C/O NJ AMERICAN WATER	34.82	62.44	67.62	71.46	76.22	0.45	0.48	0.51	0.54
NJ2004002	NJ AMERICAN WATER - RARITAN	1.32	0.70	0.95	1.24	1.47	0.15	0.20	0.26	0.31
NJ2013001	RAHWAY CITY WATER DEPT	0.22	0.17	0.18	0.19	0.20	1.32	1.38	1.45	1.51
NJ2021001	WINFIELD MUTUAL HOUSING	-0.06	0.02	0.03	0.05	0.07	0.04	0.07	0.12	0.15
NJ2101001	ALLAMUCHY TWP WATER & SEWER	0.15	0.14	0.15	0.16	0.17	0.63	0.68	0.73	0.78
NJ2102001	ALPHA MUNICIPAL WATER WORKS	0.28	0.24	0.26	0.28	0.29	0.75	0.80	0.86	0.91
NJ2103001	NJ AMERICAN WATER - BELVIDERE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ2103002	BELVIDERE SQUARE APT COMPLEX	-0.03	-0.03	-0.03	-0.03	-0.02	-0.49	-0.44	-0.39	-0.35
NJ2104001	BLAIRSTOWN WATER DEPARTM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ2106304	FOREST MANOR RETIREMENT HOME	0.84	0.69	0.81	0.94	1.04	0.30	0.35	0.40	0.45
NJ2108001	HACKETTSTOWN MUA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ2110001	AQUA NJ - BRAINARDS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ2110003	AQUA NJ - HARKERS HOLLOW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ2112001	INDEPENDENCE MUA VALLEY VIEW	-0.01	0.00	0.00	0.00	0.00	-0.16	-0.11	-0.06	-0.02
NJ2112002	INDEPENDENCE MUA HIGHLND	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

PWSID	PWSID NAME	2021 Deficit/ Surplus	Future Water Availability for 2050 (mgd)				Normalized Water Availability for 2050 (-)			
			NCNWL	NCOWL	CNWL	COWL	NCNWL	NCOWL	CNWL	COWL
NJ2113002	RIVERSIDE MOBILE HOME PA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ2113003	TRIPLE BROOK MOBILE HOME	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ2113301	CLOVER REST HOME	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ2116002	HILLSIDE VILLAGE	0.02	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ2116003	NJ AMERICAN WATER - MANSFIELD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ2116004	WARREN HAVEN NURSING H	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ2116328	CAMP HOPE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ2117002	VALLEY VIEW ESTATES	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ2117003	OXFORD MANOR LLC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ2119001	AQUA NJ INC - PHILLIPSBURG	0.92	0.96	1.12	1.30	1.45	0.27	0.32	0.37	0.41
NJ2120001	AQUA NJ INC - RIEGELSVILLE	0.92	0.96	1.12	1.30	1.45	0.27	0.32	0.37	0.41
NJ2120002	AQUA NJ - WARREN GLEN	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ2121001	NJ AMERICAN WATER - WASHINGTON/OXFORD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NJ2123002	WINDTRYST APTS	0.09	0.09	0.09	0.09	0.09	8.41	8.46	8.52	8.56
NJ2123003	COUNTRY VIEW VILLAGE, LLC	0.09	0.09	0.09	0.09	0.09	8.41	8.46	8.52	8.56
NJ1025308	PATTENBURG HOUSE	0.49	0.53	0.59	0.65	0.69	0.44	0.49	0.54	0.58
NJ1710007	HOLLY TREE ACRES SYSTEM 2	0.49	0.53	0.59	0.65	0.69	0.44	0.49	0.54	0.58
NJ1436006	ROXBURY TWP WD - EVERGREEN	0.02	0.02	0.02	0.02	0.02	1.47	1.51	1.56	1.59
NJ1427003	MT. OLIVE TWP - INDIAN SPRINGS	0.02	0.02	0.02	0.02	0.02	1.47	1.51	1.56	1.59
NJ1714300	MATER DEI NURSING HOME	0.08	0.05	0.06	0.06	0.06	2.64	2.74	2.85	2.93
NJ1208001	NJ AMERICAN - JAMESBURG	0.08	0.05	0.06	0.06	0.06	2.64	2.74	2.85	2.93

1

State of New Jersey
Department of Environmental Protection

2024 NEW JERSEY STATEWIDE WATER SUPPLY PLAN

APPENDIX L

WATER RESOURCE AND SUPPLY MANAGEMENT OPTIONS

WATER RESOURCE AND SUPPLY MANAGEMENT OPTIONS

TABLE OF CONTENTS

OVERVIEW

A legacy of water supply management experience combined with significant public and private investment have resulted in the sophisticated and highly interconnected network of public community water systems (PCWS) that New Jersey residents and businesses enjoy and rely on every day. To address increasing population, opportunities for economic growth, limited space for traditional water storage solutions (e.g., new reservoirs), the need to preserve and enhance the State's natural resources, increasing incidence of harmful algal blooms and other contamination concerns, and decreased predictability of future weather extremes, efforts must be focused to conserve and preserve available supplies, ensure the maintenance of the existing infrastructure that delivers that supply, and continue the development of new sources of supply where necessary. In order to accomplish State water supply management objectives, the DEP will assure that prudent and sound scientific practices, including the most current information and projections are applied to data presentation and policy decisions. The following are concepts that could be considered for future analysis. Many of these items are discussed in the main chapters of the 2024 Plan.

INCREASING WATER-USE EFFICIENCY

Concerted planning and significant public and private investment have vastly improved water supply storage, treatment, and distribution capabilities in the Garden State and new investments continue to do so. New Jersey's continued population growth and associated development – coupled with the potential for hotter, more erratic weather, and increasing outdoor water use and consumptive water losses – can deplete stored water supplies and lower ground and surface water levels. As a result, New Jersey must identify and implement strategies to become "water wise."

Development of an effective adaptation strategy is essential to safeguard against increased weather variability and uncertain hydrologic conditions. One of the most effective strategies is perhaps the simplest – enhancing water use efficiency. This strategy is accomplished through any one or combination of the following: *waste reduction* – minimizing water lost in transport; *conservation* –using as little water as needed to accomplish or produce something; *productivity* – getting more output per unit of water; and *substitution* – using alternate sources as a means to match the quality of water with the intended uses.

Reducing water waste and improving water efficiency continues to be the most cost-effective, least disruptive, and most environmentally sound means of decreasing demands on our water resources. Water that is not needed due to water use efficiency and conservation can be left for ecological and recreational uses or stored for later use. Maximizing efficiency also reduces pumping, treatment and distribution costs, thereby cutting energy consumption and resulting in further reductions in greenhouse gas emissions. Finally, wise use of water resources reduces the strain on the State's aging infrastructure and extends supplies to ensure water availability in times of need.

DEP continues multiple initiatives to increase water efficiency with the aim of averting future water emergencies and the need to impose water use restrictions and other costly measures during emergencies and drought conditions. Adaptive water management promotes flexible decision-making

that can be adjusted in the face of uncertainty as outcomes from management actions and other events are more clearly understood. The initiatives discussed below are divided into two sections, demand/source management and statewide water conservation strategies. The next section of this appendix discusses some options for improving this process.

DEMAND/SOURCE MANAGEMENT

As discussed in Chapter 4, excluding water used for power generation, water use declined slightly from 1990 to 2020, an average decline of 3.8 billion gallons a year. This decline is largely attributable to decreased water use in the industrial/commercial/mining sectors. The potable water use sector changes year to year but has been remarkably stable, despite increasing population. Potable water use, which includes public water systems and individual domestic wells, constituted the largest share (77%) of water use (excluding power generation) in New Jersey (fig. 3.3).

The most significant change is the decrease in water demand for power generation. The few true hydropower generators in New Jersey combined with the periodic shutdown of the generators and power plants for repairs and/or upgrades can significantly change the reported water use for this entire category. Additionally, the recent trend of closing coal-fired power generation plants, which use more water, and replacing them with gas-fired plants using less water has created a large reduction in water demand for the power generation sector. While this change decreases total water demand, it is not significantly changing consumptive water use as these uses have relatively low percentage of water lost to evaporation.

Most critical is the increasing trend of consumptive water losses. Much of the increase occurred in the public water supply and non-agricultural irrigation sectors, and specifically includes activities such as outdoor lawn/landscape irrigation, recreation, and household maintenance. The potable supply sector accounts for nearly 60% of the State's total consumptive water loss, which steadily increased from 1990 to roughly 2010, but has been somewhat lower since then, varying year by year based on irrigation needs.

Nationally, water conservation initiatives have made considerable progress through both educational measures and mandatory plumbing code standards in the Energy Policy Act of 1992, 42 U.S.C. §13201 et seq. (EPAct). EPAct measures have led to decreased indoor water use in New Jersey and throughout the nation. However, while indoor water use has trended downward over the past two decades, the increase in outdoor, consumptive water loss noted above contributes significantly to the rapid depletion of stored ground and surface water reserves, particularly during the peak summer demand months when water supplies tend to be most stressed. Statewide, public water supply demands in the summer months are roughly 20% to 30% higher than in non-summer months, primarily driven by outdoor consumptive water uses, as discussed in Chapter 4.

To curtail water waste and extend New Jersey's water supplies into the future, reserving the highest quality waters for the intended use through both source and demand management is a key feature of this NJSWSP. As noted in Chapter 4, population growth will drive water demands higher if no offsetting water conservation or other actions are taken. Without conservation, meeting future water supply needs will require significant, additional expenditures for treatment, distribution, and storage infrastructure.

Accordingly, this appendix outlines water conservation strategies that primarily target the potable supply sector, specifically focusing on outdoor "non-essential" or "non-potable" uses such as lawn/landscape watering, the single greatest source of the State's consumptive water loss. Agricultural demands are also addressed, as they can stress local water supplies in watersheds where agricultural irrigation is a large fraction of demands.

An additional component of demand/source management is the proper maintenance of transmission pipes to minimize water loss. This is discussed below as well.

STATEWIDE WATER CONSERVATION STRATEGIES

The following water conservation actions will continue to improve the State's overall water use efficiency.

1. Enhanced Public Education and Outreach
2. Reduction of Non-Revenue Water and Real Losses
3. Enhanced Outdoor Water Use Efficiency
4. Consulting with BPU on Rate-making structures
5. Promotion of New and Retrofitted Indoor Fixtures
6. Promotion of Reclaimed Water for Beneficial Reuse

All of these measures will enhance the efficient use of water and curtail unnecessary waste of limited resources.

PUBLIC EDUCATION AND OUTREACH

Since adoption of the 1981 New Jersey Statewide Water Supply Plan, DEP has developed and implemented a variety of approaches to inform the public about water supply issues, drought management responses, and individual water conservation and water use efficiency approaches. In recent years, some of this effort has shifted to digital formats such as the DEP website. In other cases, partnerships with outside entities have resulted in additional public outreach and education approaches. For example, DEP partnered with the Rutgers Cooperative Research and Extension – Water Resources Program to develop the New Jersey Water Savers (New Jersey Water Savers), which was funded through an EPA matching grant and State appropriations from the Water Supply Bond Fund in 2007. The goal of the Water Savers program was to create replicable, community-based water conservation projects and programs for various types of communities throughout the State. The projects and programs were designed to:

- educate the public concerning New Jersey's water supply availability in comparison to current and projected demands, and
- promote awareness and guidance of the most efficient use of water both indoors and outdoors by:
    - demonstrating simple and effective ways to save water;
    - educating the public about landscaping with indigenous and drought-resistant plants, efficient irrigation practices, and the use of alternate water sources (e.g. harvested rain water);

- encouraging home water audits and the integration of indoor water saving devices, including low-flow fixture/plumbing retrofits, water-efficient appliances, etc.; and
- instilling a new water use ethic through school related curricula, and empowering residents to positively impact their communities through modified attitudes and water-use habits.

The New Jersey Water Savers project created a series of water conservation pilot programs for multiple community types (suburban, rural, urban and tourist areas) that could be easily replicated across the State. This effort was followed by development of a consumer-based website (New Jersey Water Savers), which highlights the results of the pilot projects to inspire others to replicate statewide, along with expansion of one of the most successful projects, "Water Champions".

The program then extended the Water Savers project to the business sector. In this phase, two projects were undertaken to explore opportunities and incentives that would induce businesses to take water conservation measures; landscape irrigation efficiency studies/cost-benefit analyses and larger scale rain water harvesting for irrigation purposes. Educational seminars and workshops were also offered to corporate employees. The results are highlighted on the Water Savers website at: New Jersey Water Savers Goes Corporate.

The pilot projects and programs undertaken with the New Jersey Water Savers project included the following basic approaches. Some of these are continued through the New Jersey Watershed Ambassadors program funded by AmeriCorps, managed by DEP, and hosted at 20 regional entities, one for each Watershed Management Area. Others have been incorporated into Rutgers Cooperative Extension courses on landscape and grounds management (Landscape and Grounds Management Courses – Rutgers NJAES Office of Continuing Professional Education). In addition, the Delaware River Watershed Initiative continued the Water Savers approach in the Kirkwood-Cohansey aquifer area of southern New Jersey (see South Jersey Water Savers - Protecting the Kirkwood Cohansey Aquifer).

- Indoor Water Conservation programs: educate the public about the importance of indoor water efficiency and easy ways to accomplish water savings.
- Outdoor Water Conservation programs: educate the public about the importance of outdoor water efficiency and easy ways to accomplish water savings. Some of these approaches include green stormwater infrastructure (e.g., rain gardens, and natural retention basins), and Build-A-Rain Barrel Workshops and rain barrel art publicity events by Watershed Ambassadors and others; smart irrigation controller and irrigation system upgrades/maintenance education; and turf management demonstrations and programs.
- The Certification Program for landscape and irrigation workers: trains landscape and irrigation workers on the most current water efficient technologies and design techniques. Applicable courses are managed through Rutgers' Office of Continuing Professional Education-Landscape Programs at Rutgers University and award credits towards continuing education requirements. More information on current courses can be found at: Rutgers Landscape & Grounds Courses. In Phase 2 of the New Jersey Water Savers project, the Rutgers University publication, "Landscaping

for Water Conservation, A Guide for New Jersey" was updated and can be found at Rutgers Landscaping for Water Conservation.

- The incorporation of key educational programs and a model outdoor irrigation ordinance into the Sustainable Jersey certification program: Sustainable Jersey is a certification program for municipalities in New Jersey that provides tools, training and financial incentives to support communities as they pursue sustainability programs. New Jersey Water Savers and Sustainable Jersey staff have developed a model water conservation ordinance to be adopted by municipalities applying for certification. This ordinance is a priority action item in the Sustainable Jersey program. In addition, the New Jersey Water Savers have worked with Sustainable Jersey to create a Water Conservation Education tool using the New Jersey Water Savers pilot programs as models for replication. More information on Sustainable Jersey can be found at: Sustainable Jersey.

As mentioned, New Jersey Water Savers implemented a program called Water Champions, a program that has been expanded upon by DEP in recent years. Water Champions is a supplemental science-based education program about water conservation. It is designed to educate middle and high school students about the status of their current potable water supply, the impacts of overuse, and reveal opportunities in which they can increase efficiency and conservation practices as well as influence their school and community to do the same. It is the goal of the Water Champions program to create replicable curricular infrastructure to support the education of these issues and to provide a platform for authentic student research, assessment, discussion and outreach.

The program begins in the classroom where students learn about responsible water management through the Water Champions supplemental curriculum. Once the lessons have been completed, the students are tasked with performing three different water audits: a home audit, a school audit and, a business audit. In order to complete the business audit, students recruit local businesses to engage in the program. The goals of the school and business audits are to identify old and wasteful fixtures such as faucets or toilets and retrofit them with newer models that save both energy and water. Students present their results to their schools and community and encourage their communities to implement water and energy saving practices. Throughout the program, students not only learn about water conversation but also develop leadership skills through their engagement with their community.

The initial implementation of the Water Champions program in New Jersey was a partnership between USEPA and New Jersey Water Savers. It was implemented in three high schools in the Rahway and Central Delaware regions of the state between 2011 and 2013. In 2016, DEP partnered with EPA and the American Littoral Society (ALS) to continue the program in Cape May County and the Delaware Bayshore area. The curriculum was tailored to each region; the Cape May program addressed the regional concerns of saltwater intrusion, while the Delaware Bayshore program shifted its focus towards the impact of aquifer withdrawal on the streams feeding into the Delaware Bay. Through the most recent partnership with EPA, DEP and ALS have engaged with 5 schools, and performed audits and retrofits at 7 local businesses. Over 250 energy and water efficient devices have been installed at the schools and businesses, resulting in an estimated 3 million gallons of water saved.

DEP will continue the Water Champion program's implementation through the AmeriCorps Watershed Ambassadors Program. The three regional Source Water Protection Ambassadors will receive training each year to share the Water Champions lessons with New Jersey students, as well as encourage schools and businesses across the state to install more efficient devices. More information on the implementation of Water Champions can be found on the DEP's water conservation website.

DEP continues to promote water conservation and efficiency Statewide through active involvement with both the Sustainable Jersey program and the Environmental Protection Agency's WaterSense and Water Champions programs. Long-term improvements that could improve public outreach and education during both drought and normal times are discussed later in this appendix.

REDUCE NON-REVENUE WATER LOSSES AND PER CAPITA WATER USAGE

Water loss and the associated financial impacts are neither evaluated nor addressed in a consistent manner by the water industry in the United States. Water losses vary greatly throughout the nation and even among systems, with losses ranging from a few percent to over half of the water withdrawn from sources. Traditionally, the lack of a single comprehensive approach to identify and address water loss has hampered efforts to boost water efficiency. These losses are not the same as consumptive water use, where the water is lost to evapotranspiration and is essentially no longer available to the local water budget. Rather they refer to the potable supply water infrastructure. The higher the water losses, the more water is being withdrawn from reservoirs, rivers and aquifers that is not used effectively, placing higher stresses on these resources.

Current state regulations (N.J.A.C. 7:19-6.4) refer to water losses as unaccounted-for water, which means water withdrawn by a purveyor from a source and not accounted for as being delivered to customers in measured amounts. This concept has evolved through the years to be better expressed as nonrevenue water. Nonrevenue water can be defined as the unbilled water demands from in water system, expressed as a percentage (gallons of water billed/gallons of water entering the distribution system). However, as the term unaccounted-for water is somewhat antiquated due to the numerous ways water can be 'lost' in a distribution system, the Department intends to phase out this language in future rulemakings. Previously, this water loss data was collected as part of Water Conservation Plans bi-annually, for those systems with Water Allocation Permits. However, since April 2017, DEP has collected this water loss data annually through an electronic portal, including from systems who are interconnected and serve at least 1,000 people. Under pending rulemaking from the Department to fully implement the Water Quality Accountability Act (WQAA), roughly 300 PCWS would be required to submit this information, alongside the completion of the American Water Works Association Water Loss Audit. An annual review of water loss data would allow DEP the ability to better identify those systems with excessive water losses. Existing regulations at N.J.A.C. 7:19-6.4 allows DEP to require systems with excessive water loss to take appropriate corrective action. Systems with excessive water losses (15%, N.J.A.C. 7:19-6.4(a)) may be required to take corrective action, with a focus on the purveyors that have the highest water losses in each purveyor size class.

Since 2013, the Delaware River Basin Commission (DRBC) requires that water purveyors using basin water resources use a more detailed system of measurement, the Water Audit program of the American Water

Works Association (AWWA), which assesses water losses as “real” (e.g., leakage from the system) and “apparent” (e.g., data coding errors, meter error). This requirement applies to public water suppliers within the Delaware River Basin who have been issued approvals by the DRBC to withdraw and use in excess of an average of 100,000 gallons per day (gpd) of water during any 30-day period. Proponents of the methodology assert that reducing lost and/or unbilled water will more than offset the cost of implementing the new approach. More information on the AWWA Audit can be found at AWWA Water Loss Control. More information at can be found at DRBC Water System Audits.

As a result, New Jersey public water systems are subject to a mix of water loss accounting requirements and expectations. The DEP regulations use a metric that includes all types of non-revenue (i.e., unaccounted for) water, whether real (i.e., system leakage, hydrant flushing and firefighting) or apparent (i.e., theft, meter errors, accounting errors). The DRBC regulations require accounting of the multiple metrics in the AWWA software: losses per connection per day (real and apparent); Infrastructure Leakage Index (ILI). The ILI is the ratio of real losses to the Unavoidable Annual Real Losses (UARL), a theoretical indication of the leakage reduction possible with application of the current best technology. DRBC also continues to collect data on non-revenue water as a percentage of total treated water. The most recent published DRBC water audit report (2018, using 2016 data) indicates that a UARL calculation “has not yet been proven as fully valid for very small or low-pressure water distribution systems”, noting that the AWWA software doesn’t calculate UARL values for such systems. Annual DRBC data collection continues.

Actual water use by customers and the PCWS itself can be billed or unbilled, neither of which is considered a water loss. Under the AWWA methodology, nonrevenue water is a combination of water loss (real and apparent) and known but unbilled water demands (e.g., hydrant use for firefighting). The following graphic shows how total water delivered by a PCWS into water mains is subdivided into these components.

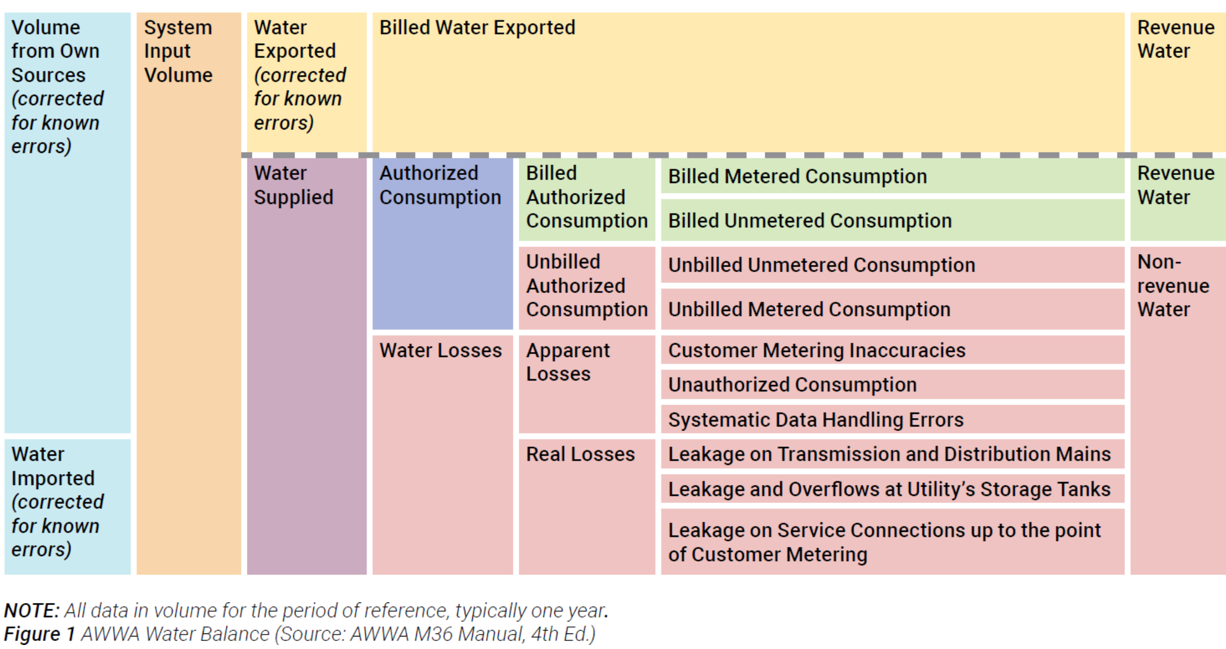

Figure L1. AWWA Water Balance Diagram (AWWA M36 Manual, 4th Edition)

Though DEP currently does not require AWWA audits be submitted for most systems outside of the DRBC's authority, DEP recognizes the value of AWWA audits. In an effort to promote the AWWA water system audit methodology, the DEP has included a section to the required Water Conservation Plan to inform permitted purveyors about the benefits of the audit and has consistently encouraged its use. After the rulemaking to fully implement the WQAA has been proposed and adopted, DEP would establish a submittal portal to ensure that data could be compiled and analyzed electronically.

The AWWA Water Audit methodology has been changing, and the current guidance from AWWA (Version 6) is that no single threshold of "real water loss" is appropriate for regulatory purposes, given the major system differences including utility age and location, water use patterns, the number of customer connections per mile of water main and per million gallons delivered, the diversity of customers (i.e., whether a major customers accounts for much of demand), etc.[1] AWWA's focus is on metrics that help utilities understand what actions will best improve the utility through loss reductions. For instance, reduction of apparent losses will shift more yield into revenue-producing flows, but it may have no impact on the total withdrawals from the source waters. Reduction of real losses, such as water leakage reductions, will increase the percentage of treated water that makes it to the water user. The need to address the diversity of utilities is certainly important.

This latest AWWA Water Audit guidance poses new challenges for determining actions. The needs of utilities for system management can differ substantially from the needs of the state for protection of public trust water resources. As a major example, in most cases the calculation of cost-effective leakage reductions (from the utility perspective) compares loss reduction costs against the cost of the lost treated water. Where project costs are less than the costs of water losses (on a present-value basis), the leakage reduction project is financially worthwhile. While valid for internal financial decisions, this approach ignores externalities, such as where water losses exacerbate an existing or future stress on the source waters. The higher the losses, the more water is being withdrawn and wasted. The more stressed that water resource is, the greater the external cost of water losses become. The AWWA methodology does allow for such externalities to be considered, but this step is rarely taken. As the Department compiles Water Audits from systems over the years, it would be better able to identify what the impacts of these externalities are and identify follow-up actions where appropriate.

As discussed in Chapter 4, water loss data from both DEP and DRBC for the years 2018 and 2019 were used to assess the current situation in New Jersey. Data from 234 PCWS yielded a statewide median water loss rate of 14.1 percent (average of 15.9%); individual results vary widely to a high of more than 50 percent. Importantly, the median results for PCWS in bedrock geology and coastal plain geology were significantly different, at 17 and 12 percent, respectively, emphasizing that there is no "one size fits all" threshold for how much water loss should be considered excessive. The AWWA methodology emphasizes this point as well. Therefore, future water loss requirements will need to consider a combination of factors, including the characteristics of the PCWS (e.g., geologic location, number of customer connections, percentages of water delivered to various customer classes, water loss per customer connection) and the extent to which the source water resources are stressed. The AWWA method

[1] Jernigan and Sayers. 2021. AWWA's Free Water Audit Software: Updates and Improvements. Journal AWWA.

provided a good sense of water losses as they affect system operations and costs, but rarely is used to also assess the impacts of water losses on source waters.

REDUCE EXCESSIVE OUTDOOR WATER USE

As prior figures suggest, residential and commercial landscaping contributes to the increased consumption of potable water supplies, particularly during the peak use growing season. This trend offsets moderately diminished per capita usage realized through indoor plumbing efficiencies and personal water conservation. It also increasingly strains surface water and groundwater sources, drinking water treatment, storage and delivery facilities, and the dependable yield and infrastructure capacity of a growing number of water systems. Unlike municipalities, local authorities and investor-owned suppliers that may impose water use restrictions at any time based on local needs (e.g., to ensure that peak demands do not cause low water pressure in the distribution system), DEP may impose mandatory restrictions only during a water emergency declared by the Governor.

While some irrigation may be considered necessary as a supplement to natural precipitation, there is growing evidence that excessive or inefficient watering leads to substantial water waste, cost and energy use. The increase in irrigation is not unique to New Jersey and is attributable to several factors, including misconceptions about the amount of water needed to efficiently irrigate turf and landscaping, inefficient sprinkler system design or operation, and lack of operational rain or soil moisture sensors on irrigation systems.

In recognition of these trends and limitations and the need to preserve high quality drinking water for potable uses, State and local policymakers should implement a variety of tools available to limit non-essential, non-agricultural, outdoor water use to what is reasonably required to support living plants and other landscape materials. Reducing consumptive water use could include measures such as the adoption of municipal ordinances (in coordination with applicable water suppliers) to regulate sprinkler irrigation. State regulatory requirements could require that new or replacement lawn irrigation systems use digital controllers to avoid water waste. DEP permits, bulk water sale contract approvals or Environmental Infrastructure Financing Program funding could also include conditions requiring peak demand reductions where appropriate to protect system capacity or source water resources.

RESIDENTIAL IRRIGATION WATER USE SCHEDULING

The adoption of irrigation standards could reduce excessive non-essential water use during the peak demand season (May-September). An example of ordinance-driven outdoor water use limits would be to allow watering two days per week within a specified time window (such as between 6-9 a.m. or 5-8 p.m.) that maximized plant health and minimizes evaporative losses. Also essential is a limit on the watering of any single area to no more than 30 minutes per day. Such a strategy should be coordinated with appropriate water suppliers in order to avoid causing undue strain on the supply system's capability to meet peak demands. Odd/even calendar day watering schedules are <u>not</u> recommended, as evidence suggests that property owners tend to over-water on their allowable day of watering, regardless of whether watering is actually needed (Vickers, 2001). While some purveyors have expressed concern that watering two days a week may result in uneven and relatively unpredictable demand peaks, this can be

avoided by distributing watering days among the town in such a way that an equal number of homes are permitted to water every day.

The two day per week irrigation regimen would allow for a thorough, less frequent saturation of the root zone to provide supplemental soil hydration when natural rainfall does not occur, as recommended in the Best Management Practices for Watering Lawns, Rutgers Cooperative Extension Fact Sheet No. FS555. This more responsible and beneficial form of irrigation sufficiently supports plant life, provides drought-proofing for many species, and would dramatically curtail the amount of water -- especially highly treated drinking water from public water systems -- being wasted. By irrigating more efficiently, over-watering is all but eliminated and turf grasses develop a deeper root system. Less frequent, deep watering has proven to be better for a lawn than frequent short watering which only feeds shallow root systems (Mangiafico, 2012). A deep root system promotes turf health, enhances weed resistance, and is more protective of the lawn during times of drought.

NON-AGRICULTURAL IRRIGATION SYSTEM TECHNOLOGIES

Advancements in irrigation technology offer meaningful opportunities for water savings, particularly using state-of- the-art sensing components (soil-moisture/rain sensors and smart (i.e., digital, zoned) controllers that incorporate weather conditions) that permit watering when conditions warrant. Devices certified through the USEPA WaterSense program should be preferred.

SMART IRRIGATION CONTROLLERS

The installation of Smart controllers on all new irrigation systems can promote efficient landscape irrigation and further preserve the State's water supplies. Smart systems are a cost-effective way to ensure that lawn and landscape watering only occurs when necessary, by taking into account soil moisture and/or atmospheric conditions before activation.

DEP partnered with Sustainable Jersey to create an Outdoor Water Conservation model ordinance for municipal consideration. The ordinance recommends a 2-day-per-week watering schedule and includes an exemption for any property utilizing Smart irrigation controllers. This ordinance is promoted as a Priority Action Item in the Sustainable Jersey Program and can be found at: Sustainable Jersey (see Water Conservation Ordinance action).

IRRIGATION SYSTEM RAIN SENSORS

An automatic rain sensor is a device that overrides the irrigation cycle of an automatic lawn sprinkler system when adequate rainfall has occurred. Rain sensors have been shown to be a cost-effective way to ensure responsible irrigation practices. The Handbook for Water Use and Conservation (Vickers, 2001) estimates that the use of rain sensors can save up to ten percent of outdoor water use at a single-family residence, estimated at 31.7 gpd. New Jersey law (N.J.S.A. 52:27D-119 et seq.) currently requires new irrigation systems (those installed after September 8, 2000) to be equipped with a rain sensor device. DEP recommends that this requirement at a minimum be extended to existing irrigation systems on all property types through legislation.

In the absence of a State rain sensor mandate, all municipalities are urged to adopt the restrictions described above by ordinance. The restrictions should apply uniformly regardless of whether the source of water is a private well or a public water system, as all such demands stress source water supplies.

AGRICULTURAL IRRIGATION SYSTEM TECHNOLOGIES

The New Jersey Department of Agriculture, State Soil Conservation Committee (SSCC), State Agriculture Development Committee (SADC), Soil Conservation Districts and the Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture collaborate on providing technical assistance and cost-share funding for implementation of agricultural production and resource conservation practices, using a combination of state funds and federal Farm Bill. The SADC is able to fund up to 50 percent of the actual cost for approved soil and water conservation projects for farms that are permanently preserved or enrolled in 8-year or 16-year term preservation programs, through the Soil and Water Conservation Cost-Sharing Program. These projects can include irrigation system improvements to reduce consumptive water losses. (See New Jersey Farmland Preservation Program | Soil and Water Grants). The NRCS likewise provides both technical services and access to funding for a variety of soil and water conservation projects that are identified as appropriate through a conservation plan, through the Environmental Quality Incentives Program (see Environmental Quality Incentives Program).

The Rutgers New Jersey Agricultural Experiment Station (NJAES) Cooperative Extension provides services with New Jersey agricultural businesses, including field research, consultation, and education on various agricultural and natural resources management issues. NJAES is not a funding source for agricultural businesses, but it provides technical support that can result in grant proposals through the state and federal programs.

In all cases, these programs have and will continue to help farm operations optimize their use of irrigation, to reduce water use and contamination while maintaining or improving crop production and profitability. It is through these collaborative and voluntary efforts that many irrigation systems have be modified from high-pressure (and high evaporation) systems to more efficient operations such as low-pressure and micro-irrigation systems.

Irrigation involves a significant energy cost to farmers. Improved understanding of soil moisture deficits, plant water demands, and actual water delivery through the irrigation system all can improve proper cost-benefit management, resulting in more sustainable farm operations and potentially higher profits. For this reason, DEP developed a pilot project in collaboration with the U.S. Geological Survey, New Jersey Department of Agriculture and Rutgers Agricultural Experiment Station to compare irrigation volumes using standard estimation methods (calculation of pump capacity multiplied by the hours of operation) versus two types of flow meters on ten farms growing a variety of crops, including nursery plants and trees, fruit trees, blueberries, and field crops.

All meters were monitored throughout the 2021 growing season (May through November). At the conclusion of the project monthly meter readings were compared to reported estimates submitted by the resident farmers. This preliminary study found that the estimation methodology most frequently used by agricultural irrigators in New Jersey does not produce statistically similar results to that of a properly

installed flow meter, which can be considered the industry standard best practice for accurately recording water withdrawals. It also found that the estimates typically exceeded the metered readings especially as monthly withdrawals began to exceed approximately 2 million gallons per month. While the study did not investigate specific causes, one major possibility is that nominal (manufacturer-specified) pump capacity (the flow rate through a pump at its designed conditions) varies from actual pump capacity (the flow rate through a pump in field conditions, which may include lengthy small-diameter piping); in other words, the same pump in two different fields would have different actual pump capacities, and those capacities are likely different from the nominal capacities. Pumping estimates are based on the nominal pump capacity, as the capacity of each specific pump has not been calibrated to field conditions and is likely lower than the nominal levels.

This was a small study that included just ten water sources, but its completion does contribute to the overall understanding of the underlying water use data with respect to agriculture. Future work should build upon this initial study by focusing next steps in areas where LFM results notes limited availability with agriculture as a dominant use.

RAINWATER HARVESTING

In an effort to promote the lowest quality water for the intended use, DEP began a residential rainwater harvesting program with the New Jersey Watershed Ambassadors program in 2014. By encouraging the use of rainwater collection for plant watering needs, potable water supply is being saved for higher quality needs. This has the added environmental benefits of disconnecting rooftop runoff from the stormwater system. It also saves energy and CO2 emissions by watering plants with water that was not treated to drinking water standards and pumped to the end user.

Since the program's inception, thousands of rain barrels have been built and distributed across the State. While the potable water savings achieved may be small compared to the State's overall use, it is also viewed as a catalyst for change from a community education perspective. This program gets the conversation started about the community's responsibility to be good stewards of their water supply and environment.

In addition, the use of large-scale rainwater harvesting cisterns has begun to gain momentum in New Jersey, in part due to the work of the Rutgers Water Resources Program. The Rutgers Water Resource Program has designed and installed a number of large-scale cisterns for landscape watering purposes and as a green stormwater infrastructure approach.

NEW DEVELOPMENT & SOIL COMPOSITION ORDINANCES

In many areas of the State, developers commonly remove native soils prior to construction. This leaves heavily compacted subsoil with little or no topsoil on newly developed residential and commercial lots. As a result, the purchaser is often burdened with years of expensive rehabilitation, including excessive applications of water and fertilizers to overcome poor soil conditions. One cost-effective alternative is for the developer to retain a balanced soil composition and soil/subsoil infiltration rates that will sustain and grow healthy turf and landscaping. This will prevent unnecessary water use and non-point source pollution from turf runoff.

To address this concern, in 2010 the Soil Restoration Act (P.L. 2010, c. 113) was adopted. This law required amendments and supplements to the Soil Erosion and Sediment Control Act, P.L. 1975, c. 251 for post-construction soil restoration through the development of "standards to provide for cost effective restoration, for specific soil types, and intended land use of the optimal physical, chemical, and biological functions". The State Soil Conservation Committee (SSCC) in the Department of Agriculture administers the Soil Erosion and Sediment Control program and was tasked with adopting modifications to the existing soil erosion and sediment control technical standards. The SSCC adopted amendments to the standards for top soiling and grading to include additional "requirements for amending soils disturbed by construction activities to address soil compaction where appropriate and allow for improved water infiltration"; restoration of compacted soils must meet specific requirements. Municipal boards and officials should work in collaboration with the local Soil Conservation Districts to ensure that these requirements are successfully implemented to reduce water demands and improve landscape health.

INITIATIVES FOR LOCAL CONSIDERATION: CONSERVATION SUBDIVISION ORDINANCES

Conservation subdivision ordinances are based on the principles of low impact development (including retention of natural vegetation), xeriscaping and other low-water and water-efficient landscaping practices as a means to lessen the need to water turf and plants. Water-wise landscape design takes into account water efficiency, native and adaptive species, rainfall and climate. According to *The Handbook for Water Use and Conservation* (Vickers, 2001), households that have converted some or all of their property to less water-dependent vegetation have reported outdoor water savings from 20-50%. As a result, landowners can enjoy less maintenance, reduced supplemental watering needs and mowing requirements, deeper root systems (enabling the lawn and plants to survive through drought), and reduced dependence on lawn chemicals.

Such ordinances may be adopted alone or in conjunction with incentives that encourage the reduction of irrigable acreage. Effective ordinances include definable goals, such as retaining forested areas or incorporating 80% low and moderate water use plant varieties into the landscape design. The details of the conservation subdivision ordinances will vary by region and therefore should be developed by local governments. Communities can incorporate their own standards to align wise water use principles with their specific environmental goals.

More resources on water conservation in New Jersey can be found at: DWSG Water Conservation.

RATE-MAKING AND BILLING

In an effort to help utilities develop rates that reflect the true cost of treating and delivering water and promote long-term maintenance and operation of the system ("full-cost pricing"), the USEPA has created an extensive website on water utility financial tools: USEPA Financial Technical Assistance and Tools for Water Infrastructure.

The New Jersey Board of Public Utilities (BPU) authorizes rates that investor-owned public utilities may charge customers for the treatment, distribution and use of water. In establishing equitable rates, the BPU makes every effort to protect the interests of consumers, ensuring they are not overcharged for the

cost of services. The BPU also oversees the water rates of a small number of systems (about 40 of the approximately 600 PCWS in New Jersey) but who serve about 3.1 million customers.[2] Municipal and local/county/authority-owned and operated systems determine and implement rate structures in accordance with New Jersey Department of Community Affairs (DCA) guidelines, but the DCA does not have a rate approval system analogous to that of the BPU. DEP works with BPU, DCA, privately owned purveyors, and municipal systems to evaluate water conservation rates and water pricing structures that encourage conservation and allow recovery of conservation program costs through water rates. N.J.A.C 7:19-6.5(a)4 states "all public community water systems shall file water rates which provides incentives for water conservation with DEP and the Board of Public Utilities." A recent study of water utility rates (Van Abs, et al., 2022)[3] found that the weighted average household cost for drinking water was roughly $345 for a household using 45,000 gallons of water per year.

WATER CONSERVATION RATES

Conservation rate structures, whereby rates increase commensurately with the volume of water used, are an effective method for reducing water demands. When compared to other conservation methods such as retrofit rebate programs or sprinkler ordinances, conservation rates are straightforward and cost efficient to implement. However, improperly set rates or unanticipated changes in water use and demand may positively or negatively affect the revenues of water suppliers. According to Janice Beecher, Ph.D., of the Institute of Public Utilities, Michigan State University, a review of over 100 studies of the price elasticity of demand concluded that a 10% increase in price lowers demand by a range of 2 - 4% (Beecher and others, 1994). This equates to an expected water savings in the potable supply sector of roughly 28-55 mgd of water per day in New Jersey. However, conservation rates are less effective for both high- and low-income households, for different reasons. Water costs for high income households are a small percentage of income; increases do not drive behavior significantly. Low-income households already tend to have financial stresses that drive reduced water use, often have no outdoor water demands, or are in rental housing where they do not pay water bills directly. Therefore, it is in the middle income ranges that conservation rates have the greatest effect on residential demands. Also, setting the top water demand for the first tier requires consideration of different household sizes, so that larger households are not penalized for larger total demands that reflect a similar per capita demand as smaller households. Finally, the benefits of conservation rate structures can be diluted by heavy dependence on fixed charges, where a change in water demand results in a much smaller change in the water bill.

Historic pricing practices quantify the costs of capturing, treating and distributing water, without accounting for the benefits of conserving water. The various conservation rate structures identified below are designed to achieve conservation through economic incentives. This method of demand management enables water purveyors to postpone the need to construct costly new or expanded water/wastewater

[2] The BPU, in a limited number of cases, reviews rates charged by municipal public utilities if the utility provides water service to more than 1,000 billed customers in another municipality and the utility charges a different rate to customers in the separate municipalities.
[3] Van Abs, D.J., T. Evans and K. Irby. (2022). Assessing Statewide Water Utility Affordability at the Census Tract Scale. AWWA Water Science, https://doi.org/10.1002/aws2.1287.

treatment plants or supplies. The costs of conservation will be far less, since greater investments are required for infrastructure improvements and supply development.

Furthermore, two of the rate structures listed below (inclining block rates and seasonal rates) specifically protect the interests of the average water consumer when a select group of users cause the increased peak demand. By charging a higher rate for those who use more water, costs associated with any increased maintenance and development of infrastructure can be passed on to those using the resource excessively, instead of passing the costs on to all consumers in the form of "across the board" rate increases. Conservation rate structures are designed to help motivate consumers to reduce their excess water usage. When consumers choose not to cut back, they (not the average user) pay to cover the costs of building and maintaining the additional infrastructure necessary to provide that level of peak usage.

Water conservation rate structures for consideration include:

- Inclining Block Rates: An inclining block rate structure is one that encourages conservation by charging higher rates as use of the commodity increases. The lowest rate is based on the amount of water determined to be appropriate for basic human consumption and sanitary needs and other reasonable uses. Often such rates include an allowance for seasonal water use as well. Based on such allowances, a relative allocation figure is assigned and water usage above this amount is subject to the higher rates. In some cases, water utilities incorporate an initial water volume within their fixed charges, which works well with an inclining block rate structure.
- Seasonal Rate Structures: Outdoor water use during the peak seasonal demand period, May through October, presents the greatest strain on water availability and utility infrastructure, because it coincides with relatively lower rainfall and higher evapotranspiration rates. In New Jersey, seasonal outdoor water use has risen significantly since the 1970s, largely attributable to continued suburbanization, vast increases in residential and commercial lawn and landscape areas and, ultimately, dramatic increases in irrigated acreage. In response, stream, river and reservoir depletion occurs at a much faster rate than during the rest of the year. In many communities across the country, water systems have instituted seasonal conservation rates to combat water supply shortages and other water treatment/ delivery issues during the peak demand season. Generally, higher rates are imposed during the summer season, either for the full demand volume or for only that portion of demand that exceeds non-summer demands, coinciding with peak use and low water availability. The concept of differential water use rates aims to allow for reasonable seasonal use while discouraging excessive use and water waste. The increased rates also effectively appropriate the financial burden associated with water system infrastructure enhancement and maintenance to the subset of water users that are causing the increased peaks. Similar to inclining block rates, this rate structure commonly consists of three inclining tiers. These rates are usually based on water allotments for average winter consumption, with the second tier reflecting what is considered to be reasonable outdoor use for the area, and the third tier representing what is considered to be excessive outdoor use for the area. The seasonal component will vary by region and service area, reflecting the current and projected supply and demand scenarios for an area.

Water use qualifying for different tiers can be determined through a simple estimation of how much is typically used for average winter consumption with seasonal usage above that amount being subject to higher use tiers. For a more accurate accountability of what is actually being used for non-potable outdoor irrigation, irrigation sub-meters may be used. This practice is also applicable to areas with high summer tourism demands; it is equitable because infrastructure must be maintained year-round for seasonal use. Through the use of seasonal rates, the non-summer customers (i.e., year-round residents and businesses) do not pay a disproportionate share of annual utility revenues.

- Decoupling Rate Structures: Some utilities have found that effective water conservation efforts significantly reduce water consumption, which in turn reduced their earnings and (for investor-owned systems) profitability. Seasonal rates, especially, can result in large revenue streams from one year to the next, due to weather-related changes in outdoor water demands. One option is to periodically modify the rate schedule (price per volume) to offset the loss in volume; users that conserve will then pay less than those who do not. A second option is to use the more variable part of the billing to build utility financial reserves, which can then be drawn down over time to defer rate changes or to fund smaller capital projects out of reserves.

  A third but rarely used option is decoupling. By separating or decoupling the utility's recovery of fixed costs and profits from the volumes of product delivered, the utility could devise a rate structure that sufficiently covers overall costs and regulated profits regardless of the amount of water sold, thereby reducing overall water consumption and reducing adverse impacts to a utility's financial condition. Essentially, the utility would rely primarily on fixed charges rather than volumetric charges, a common approach for sewer utilities but uncommon for drinking water utilities. In decoupling water utility sales from earnings, the disincentive to promote the conservation of water is eliminated. Because decoupled rates do not provide a financial reason for the end user to conserve water, this type of rate structure should be linked to mandatory water conservation programs that educate customers about how and why they should reduce their overall water consumption. Thus far, there are limited applications of decoupling rate structures in the United States for water purveyors. However, decoupling rate structures have shown significant success in both the electric and natural gas industries. As an alternative to inclining and seasonal rate structures, further research and consideration should be given to the implementation of decoupling rate structures.

INDOOR PLUMBING AND APPLIANCES

Through the DCA and the Uniform Construction Code (UCC), New Jersey has required the installation of water efficient plumbing on all new construction and development since 1992. The State plumbing code also requires the installation of water efficient models anytime a fixture is replaced, or a property is renovated. Beyond State-mandated water efficiency standards, the Federal Government has also played a substantial role in ensuring water use efficiency standards in plumbing fixtures. The 1992 Energy Policy Act (EPAct) established maximum allowable water flow rates for plumbing fixtures including toilets, urinals, showerheads and faucets for new and renovated residential and nonresidential facilities. A major

goal was to reduce energy demands from indoor hot-water uses; reductions in water utility energy demands were an additional benefit.

The flow rate limitation standards became effective for various plumbing fixtures between the years of 1994 and 1997 and are required of all devices manufactured or sold within the United States. The EPAct standards were expected to produce six to nine billion gallons per day in water savings by 2020. Furthermore, the USEPA has gone farther with fixture efficiency by encouraging the development and use of the lowest water using technology through the WaterSense Program. Similar to the Energy Star program, WaterSense is a partnership program that seeks to promote water efficiency and enhance the market for water-efficient products, programs, and practices. WaterSense helps consumers identify water-efficient products and programs by providing a label to indicate that the products and programs meet water efficiency and performance criteria. WaterSense labeled products perform well, help save money, and encourage innovation in manufacturing. In 2008, DEP joined as a State partner of the WaterSense program. For more information pertaining to WaterSense please visit EPA Water Sense. A third national program relevant to water conservation is the Energy Star program (Energy Star), a certification program for energy-efficient appliances. Clothes washers are a major water-demanding appliance that has Energy Star certification requirements; the two issues work together because heating water for the washer is energy-intensive, and the less water is used (a reduction of 33 percent or more from non-certified washers), the lower the energy demand. The EPAct requirements, WaterSense and Energy Star programs contributed to a 40 percent reduction in per capita water demands from 1970 to 2010 (Diringer, et al., 2018). Evidence from New Jersey indicates that per capita water demands continue to decline.

In 2021, Governor Phil Murphy signed into law P.L. 2021, c. 464 which established minimum efficiency standards for several categories of residential and commercial appliance. This includes stricter water efficiency standards for products such as faucets, showerheads, spray sprinkler bodies, urinals, and toilets. The Department is developing a rule proposal to fully implement these standards. While a complete analysis of the impacts of these standards is pending, products which are WaterSense labeled use at least 20% less water than standard products.

OUTREACH PROGRAMS AND ENCOURAGING INFRASTRUCTURE RETROFITS

Considering that the average volume of water saved in a home with low-flow fixtures and appliances is approximately 35% of indoor water use, working towards retrofitting all properties with water efficient fixtures and appliances will further reduce indoor water demands. (Mangiafico and others, 2012).

Home water audits are a good method for identifying ways to conserve water within a home and to detect leaks. Typically, they are used as a precursor to installing water saving fixtures and appliances and can be done by the homeowner or by a participating utility and/or municipal inspector. When implemented in conjunction with retrofit programs, older homes can gradually become as efficient as newer homes, while newer homes will have the ability to find additional conservation options.

In addition to home water audits, plumbing retrofit ordinances and programs are effective ways to help ensure that older homes begin to make upgrades to low-flow fixtures. Examples of this are the adoption

of a local ordinances requiring new homes and remodeling jobs to use low flow and/or WaterSense fixtures or incentivizing low flow and/or WaterSense fixtures through retrofit programs such as giveaways, subsidies, and exchanges of outdated fixtures for the latest in low-flow models.

A significant impediment to the implementation of home water audit and retrofit incentive programs is cost. However, most of these improvements have pay-back (return on investment) periods that they are worthwhile to households. Public water systems have invested in outreach programs to help households that are experiencing financial inability to pay water bills, and energy utilities help support energy-saving audits for qualifying households that can point to water-saving appliances and fixtures. A major constraint is in helping households that rent, as the landlord is often the owner of all major household appliances and water fixtures.

METERING FOR WATER CONSERVATION

Source and service metering is a necessary component to New Jersey's water supply management program as it allows accurate accounting of water diverted, non-revenue water, evaluation of leak detection and repair programs, quantification of withdrawals in stressed areas, and motivation for individual users to understand their water use habits and take action to make a reduction. Metering of all water supply sources is a requirement of all Water Supply Allocation Permit and Registration holders. In addition, according to the current Water Supply Allocation Permits rules, certain water supply purveyors must meter every service connection. These efforts can be enhanced through increasing and enforcing meter accuracy standards and through sub-metering.

- Meter Accuracy: As per N.J.A.C. 14:9-4.1(b), the BPU sets forth a testing frequency schedule based on meter size. Most home meters are 5/8-inch and must be tested every 10 years or 750,000 gallons (whichever comes first). Since meter testing must take place under certain conditions, the meter must be removed and replaced at that time. If the meter is in good working order, it can be reinstalled at another location in order to save time and money. At this time, this requirement only applies to water utilities under BPU's jurisdiction. However, the 10-year/750,000 gallon code is the industry standard and could apply to all service areas/ connections regardless of ownership.
- Uses of advanced meter technology: Many utilities in the State of New Jersey have implemented Automated Meter Reading (AMR) systems. These systems send a radio signal with the meter readings at assigned intervals. These devices eliminate the greatest cause of inaccurate or missing meter readings - needing to gain access to a home to read the meter. These systems allow the purveyor to read the meter, either through a drive by system or remote antennae. This greatly reduces the cost and time needed for meter reading and promotes the ability of a water purveyor to bill monthly. These systems can also be used to provide the customer with information on excessive water use. Whether providing notification of excessive use in a timely manner (within 2 weeks of the event) or monthly billing, the customers will receive a timelier account of their water use, allowing customers to make adjustments as needed to avoid higher water bills, and give customers the ability to discover service line, plumbing or irrigation system

leaks sooner, allowing for prompt repairs and reducing the magnitude of high bills caused by leaks.

- **Sub-metering**: In some instances, including multi-family dwellings and non-residential buildings, service meters are provided for the entire building or complex instead of for each individual user. Requiring metering for each individual user in complexes such as these and for separate meters for indoor and outdoor use is not within the scope of DEP's regulatory authority. Further investigation and consideration should be given to whether and how sub-metering could be implemented in New Jersey.

RECLAIMED WATER FOR BENEFICIAL REUSE

While Reclaimed Water for Beneficial Reuse (RWBR) has gained recognition as a useful water supply management tool in sections of the country with limited or constrained water resources (e.g., southern Florida, Arizona and southern California), in the past it has received less acceptance and limited implementation in New Jersey. With continued population increases and an ever-expanding competition for limited water supplies, applications of RWBR in New Jersey are gaining ground as a viable and attractive water source alternative for specific purposes. "RWBR involves taking what was once considered waste product, giving it a specialized level of treatment and using the resulting high-quality reclaimed water for beneficial use. In other words, the reclaimed water is used to replace or supplement a source of groundwater or potable water" (DEP, 2005). RWBR has the advantage of being feasible at both the development and the utility scale. For example, several residential towers in Battery Park City use an internal RWBR to use treated wastewater for toilet flushing water, resulting in a 55 percent reduction in potable water demand and a 60 percent reduction in wastewater generation (Battery Park City Wastewater & Rainwater Reuse). On a far different scale, Bergen County Utilities Authority sends treated wastewater to a nearby electrical power generating plant.

RWBR is consistent with and supportive of state planning and economic development goals in that it ensures potable water is reserved for use in appropriate residential, commercial and industrial applications. RWBR also assists in the stabilization of increasing potable water sector demands allowing for more accurate forecasting, which can be valuable in the avoidance of demand-driven and drought-related water shortages. Increasingly, water users are encouraged to consider RWBR as a viable water supply option to meet growing demands facilitated by outdoor water use while protecting water supply resources, particularly in those areas where regional wastewater systems discharge to the ocean, thereby depleting local/regional water supplies.

The importance of RWBR in New Jersey gained ground during the emergence of drought conditions in 1999 and was reinforced during the subsequent and more severe 2002 drought event. In response, DEP approved more than 70 temporary reuse authorizations under administrative orders issued during the water emergency. This allowed utilities and municipalities to reuse water for activities such as street sweeping, sanitary sewer jetting, and roadside corridor maintenance.

Since that time, DEP has increasingly advocated RWBR as a drought mitigation strategy and as a long-term water supply management tool, particularly for highly consumptive, non-potable purposes. To that end, RWBR has become an integral component of DEP's goal of matching water quality with the intended

use, thus reserving the highest quality sources for drinking water and other potable needs. RWBR represents an opportunity for DEP to work towards comprehensive management of water through the coordinated efforts of the programs that manage wastewater and water supply.

The agency also has moved to promote coordination among the programs responsible for the planning and permitting functions associated with water diversions and wastewater discharges. For example, it may not be appropriate to approve RWBR proposals that would reduce stream flow in waters that currently receive discharges of treated wastewater. Highest priority for RWBR will be using treated effluent from wastewater facilities that discharge to saline waters.

DEP Water Allocation Rules require permit applicants to submit information substantiating the need for the proposed allocation and supporting the designated choice of water resource for the allocation (N.J.A.C. 7.19-2.2(g)). The provision also requires applicants for non-potable diversions to document that the proposed water source is of the lowest acceptable quality water for the intended use. DEP is proposing to strengthen these rules to further discourage new or increased allocations for highly consumptive, non-potable purposes, except as possible sources of back-up emergency supplies to RWBR.

Additional resources on RWBR include DEP's "Technical Manual for Reclaimed Water for Beneficial Reuse". Further, the issuance of a NJPDES General Permit for RWBR for restricted access simplifies the authorization process for restricted access reuse projects. Reuse is steadily gaining momentum, with increasing volumes of reclaimed water being utilized year after year. More information regarding reclaimed water for beneficial reuse and associated programs can be found at DEP RWBR website.

Over the years, the NDJEP, specifically the Division of Water Quality (DWQ) has been working to promote and implement the beneficial reuse of wastewater for domestic and industrial wastewater dischargers via the New Jersey Pollution Discharge Elimination System (NJPDES) permitting program. The Bureau of Surface Water and Pretreatment Permitting program currently has issued over 125 NJPDES/Discharge to Surface Water permits that allow permittees to implement, upon approval, a reclaimed water program for a variety of public and restricted access uses. Permittees file their annual use report detailing the water use activities taking place and the volume of reclaimed water utilized. A detailed annual accounting of these activities can be found at New Jersey Wastewater Reuse Program - Reuse Report Data.

In an effort to promote RWBR, DEP instituted several financial assistance programs to aid the financing of new infrastructure and additional treatment requirements for RWBR projects. This included making low interest loans available through the Environmental Infrastructure Financing Program. A Determination of Environmental Benefit (See DEP DWQ Determination of Environmental Benefit Application) issued by the Department can be submitted to the New Jersey State Department of Treasury, Division of Taxation for a corporate business tax credit and/or sales tax refund for the eligible treatment or conveyance equipment purchased for the exclusive purpose of reusing further treated effluent in their industrial processes.

IMPLEMENTING RWBR

The first application of public access RWBR was implemented in the spring of 2002, when Evesham Township began using reclaimed water for irrigation of its municipal golf course. The project was an immediate success, allowing for the effective maintenance of the course through the drought that summer. In August of 2006, New Jersey's first residential application of RWBR was implemented at an active adult community in Burlington County, where reclaimed water now provides an alternate water source for irrigating the extensive grounds of the community.

See Table L1 for a summary of total annual water use savings through the use of RWBR from. 2021 RWBR data is the most recent data available. Refer to New Jersey Wastewater Reuse Program - Reuse Report Data for the most up to date information.

Table L1. Reported RWBR Water Use

Year	Reported Use (bg)
2005	1.175
2006	2.23
2007	2.6
2008	3
2009	3.24
2010	4.2
2011	4.45
2012	5.07
2013	5.96
2014	9.82
2015	12.78
2016	4.59
2017	13.63
2018	9.34
2019	11.18
2020	9.89
2021	13.27
2022	13.43

The success and future promise of the above RWBR projects provide reassurance and incentive for more widespread implementation. Thus far, these demonstration projects have confirmed the critical need for cooperation among agencies responsible for wastewater treatment and the delivery of adequate water supply within a region.

DEP recognizes that RWBR presents challenges when compared to the relatively low costs and ease of pumping groundwater or access via existing potable infrastructure. However, the simplification of the regulatory process and the financial incentives make RWBR a more attractive management tool for wastewater utilities and highly consumptive/depletive non-potable users throughout the State. As areas of the State that were once "water-rich" face stresses due to increased consumptive uses and the exportation of wastewater (via discharges) to the ocean, bays, and tidal rivers, RWBR remains a viable option to reduce stresses upon local water sources.

As the true costs of treating water for potable uses are fully realized, especially compared to pricey alternatives such as desalination, the cost differential between RWBR and traditional potable water supplies can be expected to diminish. DEP will continue to promote RWBR, recognizing the need to develop strategic plans and goals to ensure long-term program success and will investigate the possibility of using a true-cost-of-water[4] approach.

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[4] The True Cost of Water combines three types of costs: (a) direct costs: price of water, operational costs and investments in water infrastructure; (b) indirect costs: administrative, legal and corporate social responsibility costs; and (c) costs related to risks such as operational risks: e.g., water shortages, flooding, financial and regulatory risks, costs related to reputational risks: e.g., temporary loss of license to operate, boycotts. Adapted from Veolia Water NA.

APPROACHES FOR IMPROVING NEW JERSEY'S WATER SUPPLY FUTURE

EFFICIENT USE OF THE STATE'S FRESHWATER RESOURCES

Water conservation and water use efficiency can save water utilities and the State considerable capital expenses over the long term by delaying or even eliminating the need to develop new or expanded potable water supplies and additional infrastructure. These measures also reduce stress on natural water resources.

The goals of DEP's existing water conservation policy include:

- promoting a responsible water use ethic by all users;
- reducing real water losses;
- reducing indoor water demands;
- reducing consumptive water demands, particularly of potable water sources from activities such as outdoor water use, which this Plan has recognized as a growing concern; and
- increasing use of non-potable sources of supply for non-potable purposes, including through Reclaimed Water for Beneficial Reuse (RWBR).

A responsible water use ethic can be achieved through a combination of regulatory and educational efforts. DEP regulations ensure that water allocations are appropriate to the anticipated needs of the permit holder, whether a self-supplied industrial or agricultural water user or a public water system. DEP also has educational materials on its website and has supported efforts by Rutgers Cooperative Extension and others to improve public understanding of the value of water and the importance of water use efficiency.

Regarding the last goal, DEP has advocated RWBR as a drought mitigation strategy and as a long-term water supply management tool in appropriate locations, particularly for highly consumptive, non-potable purposes. RWBR should remain a component of DEP's goal of matching water quality with the intended purpose, thus reserving the highest quality sources for drinking water and other related needs. (See discussion in Policy Item #5 below).

REDUCE REAL WATER LOSSES

The reduction of water losses will be critical to optimizing water demands through the year 2050, as discussed in Chapter 4 for PCWS demand projections. Three major options are available for consideration.

1. First would be to have a consistent approach for assessing real and apparent water losses using a consensus approach that provides the most useful information possible. As DRBC already requires use of the AWWA Water Audit Methodology and DEP encourages (but does not require at this time) the same, DEP would require that all regulated under the Water Quality Accountability Act conduct periodic AWWA Water Audits, reporting losses per connection per

day (real and apparent) and ILI values; reports to the DRBC and DEP would thus be the same. Initially, this approach could continue to collect an overall real water loss percentage as a rough indicator of distribution system integrity, but this value should only be used for targeting further evaluation.

2. The second action for consideration is to establish a set of thresholds for water losses that provide a good indication of which utilities need to focus attention to real or apparent water loss reductions because their metrics are not in line with effective utility management practices. The thresholds should be established once there is a sufficient database (including the multiple years of data submitted to DRBC) and should include consideration of the water resource externalities caused by excessive real water losses. As one example of a data need, multiple years of data would help determine the extent to which real water losses vary year-to-year within individual systems (i.e., periods of high demand may have different water loss percentages than periods of low demands). Based on available information, a single statewide threshold is not appropriate. More research is needed, but requires statewide results using a consistent analysis methodology, such as the AWWA methodology. Therefore, this action would follow the first, with the thresholds being based upon a detailed analysis of the audit results.
3. A third action would be to directly relate the results from the water audits to requirements under the Water Quality Accountability Act. DEP is authorized to develop regulations implementing the WQAA. Under this policy option, the rules could require that systems with unusually high losses demonstrate that their capital projects contribute to a reduction in losses toward the thresholds. The policy should acknowledge that other asset management projects may have higher priority than water loss reductions (e.g., MCL compliance), but the higher the water loss, the greater the burden of proof that loss reductions are a lower priority. This approach could be implemented prior to the first two policies, using a high threshold of total water loss (e.g., above the 75th percentile value of current data).

REDUCE INDOOR WATER DEMANDS

Indoor water demands in residential and commercial buildings have been declining for decades, as discussed previously. Much of this reduction is driven by improved water efficiencies in plumbing fixtures and water-using appliances in response to federal regulations, national certification programs (WaterSense and Energy Star), and uniform building codes. A major question is whether the Building Code reflects modern technology. For example, the EPAct regulations require that toilets use a maximum of 1.6 gallons per flush. The WaterSense threshold is 1.28 gallons per flush, or 20 percent less. However, multiple models are available at just 0.8 gallons per flush, half of the EPAct requirement. In addition, because the Building Code only addresses plumbing fixtures, not appliances, the large savings available from efficient clothes and dish washers are not mandated. There are no data on what percentage of appliances sold in New Jersey meet either WaterSense or ENERGY STAR requirements. In addition, there is a major difference between building owners and renters, regarding financial incentives for reduced water demands. Residential renters often do not pay water bills directly, especially for multi-family housing, as no sub-meters allow for demand tracking. One option is to assess whether updates to the Uniform Building Code or other regulations would achieve a significant reduction in water demands beyond current trends.

Another approach for reducing indoor water demands is to help water customers understand their water demands in comparison to others, between seasons, and with identification of possible water leaks within the house, which are not addressed by water loss audits at the utility scale. Digital (aka "smart") metering combined with online customer portals and notification systems can help inform customers and encourage more efficient water uses.

There are two major policy questions regarding smart metering. First is the extent to which state government (e.g., BPU, DCA, DEP) should allow, encourage or require transition to smart metering, and what metrics should be used to determine the most beneficial approach. The related question is how to allow utilities to include smart meter system costs in their budgets, which affects rate schedules. Smart metering is more costly upfront (though requiring fewer operational resources for meter reading and billing) and involves additional cybersecurity concerns and costs. Given the 15 to 20 year lifespan of residential water meters, making the right decision to replace them with analog or digital meters is important for future water management capacity and net utility costs. Choosing smart meters will be more important for utilities with elevated water losses, high per capita residential water demands, or stressed source waters. One policy option is to allow smart meter installation and use (and rate recovery) only where a utility makes a sound case for doing so. This approach is used by BPU in rate cases. Another option is for state government to provide guidance on smart metering but otherwise leave the issue to utility choice. A third option is for the state to require smart metering (and allow its costs) where utility water losses or source water stresses show a strong cause for action, and otherwise to leave the issue to utility choice.

The second policy issue is whether and to what extent the state government should provide guidance or rules for how smart meter data are provided to customers. This question is less time-sensitive, as smart meters can be put in place for utility-centered reasons and then the customer interface can evolve. Still, part of the justification for smart meters (and ratepayer impacts) is the customer benefits. One problem here is the ongoing software evolution and the costs of data management for smaller utilities. One option is for the state to provide only basic guidance or rules on customer data access and privacy. Another option is for the state to develop more detailed guidance on building customer data interfaces without specifying a software package.

REDUCE CONSUMPTIVE WATER DEMANDS

Residential outdoor irrigation is the other major consumptive water demand in New Jersey. Residential irrigation demand is seasonal and weather-dependent, but it also is affected by landowner preferences, awareness of lawn and landscape watering needs, and local ordinances. It is common for people to misunderstand plant water needs, as few people are trained in this area and many people want their lawns to be green despite the fact that cool-weather grasses will tend to brown out in high heat, regardless of lawn watering. Outdoor water uses for low and medium density development may increase as summer average and peak temperatures increase through global warming (Arbues et al., 2002; Corbella and Pujol 2009), to address increased soil moisture deficits caused by the rising temperatures (Dawadi and Ahmad 2013; Dziegielewski and Chowdhury 2012). These increased needs may offset improvements in lawn irrigation practices.

Several methods for reducing residential outdoor irrigation demands were previously discussed in this appendix. These approaches can be implemented in two ways. First, DEP could require that a PCWS with large lawn areas within their service area identify areas with high summer peak demands and develop approaches to minimize consumptive water demands. Second, as discussed previously, changes to state laws could incorporate provisions for better irrigation controllers on existing, replacement and new lawn irrigation systems. Similar requirements could be extended to major non-residential lawns, such as business campuses. Finally, utilities can incorporate seasonal demands into their rate schedule, where customers would pay a higher rate for summer demands that exceed their non-summer demands. Because summer peaks are not as predictable as normal demands, the utility would need to ensure that a low-demand summer does not create a problematic revenue shortage; methods include putting second-tier revenue into rate stabilization funds, reserves, a fund for capital projects, conservation incentive programs, etc. The use of summer rates likely would improve affordability issues, as lower-income households often use less water during summers than other households. A second policy option is for the state (e.g., DCA with support from DEP and BPU) to develop general guidelines for rate schedule development, incorporating useful concepts from the AWWA M1: Water Rates, Fees and Charges. This would help publicly-owned utilities understand the implications of different rate structures and perhaps would encourage the use of common units (e.g., thousands of gallons) and a better balance between fixed and volumetric charges. Guidance could help a utility overcome customer resistance to increased outdoor water demand costs.

Agricultural irrigation is a relatively small percentage of total water demand in New Jersey, when compared to total statewide water uses, and almost none of it comes through public water supply systems. However, in some watersheds, agriculture is the primary total demand. Agricultural irrigation is a much larger percentage of total <u>consumptive</u> water demands, which means that in a watershed where agriculture demand is high, it may constitute most of the consumptive water loss. Agricultural irrigation also tends to be highest at the same time that natural water resources such as streams and shallow aquifers are most stressed, which exacerbates the water stresses. Yet the crops are more likely to fail without irrigation at this time. Depending on the crop and the farmer, irrigation technology may range from high-pressure spray irrigation (generally seen as low-efficiency due to excessive evaporation) to micro-irrigation (a high-efficiency but higher-cost technology that is appropriate for some crops but generally not for field crops such as grains). For these reasons, New Jersey and its farmers benefit from agricultural irrigation but also have an interest in making sure that water withdrawals occur only when truly needed, as required by N.J.A.C. 7:20A.

Agricultural irrigation is <u>very</u> different from indoor residential, commercial and industrial water demands, as agriculture is highly weather dependent. Residential lawn irrigation also is weather dependent, but it gets bundled with other public water supply demands and the browning of a lawn doesn't threaten a homeowner's income. Golf course irrigation is more equivalent to agricultural irrigation, as both are growing a crop, but most golf courses are required to have water allocation permits; agriculture is treated differently, receiving water use certifications that require less detailed information. The difficulty is knowing how much agricultural irrigation water is needed at a watershed level, when each farm will have

different needs based on soils, crops, planting times, local rainfall events, etc. Some factors can be known ahead of time, but not local precipitation.

Another difficulty is that agricultural irrigation is mostly measured through a simple calculation of pumping capacity times pumping duration (e.g., 100 gallons per minute for 100 minutes is 10,000 gallons). Every NJSWSP to date has noted that agricultural withdrawal data are more uncertain than other withdrawals that routinely use metering. As discussed previously, DEP conducted a pilot study to evaluate the effectiveness of agricultural metering, finding that metered withdrawals tend to be less than reported withdrawals. The cost of accurate metering has been dropping with new technology, however, creating the potential for improved understanding of actual irrigation quantities.

At this time, DEP has not concluded that statewide changes are necessary for agricultural water reporting. There are, however, several options for evaluating this issue further. One option to consider in conjunction with the Department of Agriculture would be mandatory metering using cost-effective technology only for the largest agricultural water use certifications and for those certifications that constitute a large fraction of the total water availability for a specific watershed, especially for stressed watersheds. These data might then be used to help assess and calibrate the water use information from other farms. Requiring meters for any agricultural operations may require a statutory or regulatory change. A second option is to specifically incorporate the concept of variability in the agricultural water use certifications, so that a low use in one year does not affect the certified volume. Options include multi-year volumes or peak year volumes with an expectation of lower years. Provisions of N.J.A.C. 7:20A-2.4(d)4 might be clarified to allow the concept of variable annual needs to be included in a water management plan developed for a farm unit. Requirements of N.J.A.C. 7:20A-2.5(a)11 currently require information demonstrating that "under standard operating conditions" certain water impacts will not occur, but there is no definition provided of "standard operating conditions"; inclusion of inter-annual variations in irrigation needs may be useful here. A third option combines continued technical and cost-sharing assistance to farmers toward use of the most efficient but cost-effective technology being used for agricultural irrigation, such as drip irrigation in place of broadcast irrigation.

NEW JERSEY'S APPLIANCE AND EQUIPMENT EFFICIENCY STANDARDS

In 2022, the legislature passed The Appliance and Equipment Efficiency Standards Act (Act) (P.L. 2021, c.464). The Act establishes that beginning January 18, 2023, no person shall sell, offer for sale, lease or install a new product identified within the legislation, unless the new product includes a mark, label, or tag denoting the product meets or exceeds the prescribed efficiency standards. The law also prohibits the installation for compensation of any product identified in the law unless the new product has a mark, label, or tag denoting the product meets or exceeds the standards. The water-related categories defined in the law include commercial dishwashers, commercial steam cookers, faucets, portable electric spas, showerheads, spray sprinkler bodies, urinals, toilets, and water coolers. The Appliance Standards Awareness Project estimates that 136 billion gallons of water would be saved through 2035.

WATER SYSTEM RESILIENCE

New Jersey is the eleventh largest state by population and by far the most densely populated, with roughly 90 percent of all residents (and associated businesses and government facilities) being served by PCWS. The water infrastructure represents massive expenditures over more than 150 years. The Water Quality Accountability Act of 2017 (WQAA) establishes a formal framework for ongoing asset management of water systems, including the treatment and delivery components. The WQAA was adopted in recognition of aging infrastructure and increased issues with water system resilience in the face of more severe wet weather events. It enhances DEP authority to ensure proper maintenance of water systems. Water system resilience also requires attention to each public water system's ability to provide sufficient water through intense droughts, through a combination of internal and external resources and emergency connections to other systems. Finally, resilience and sustainability of a PCWS requires that its customers pay their bills; therefore, affordability is recognized nationally as an aspect of utility resilience.

PROMOTE WATER SYSTEM INFRASTRUCTURE RESILIENCE

Management of distribution system water losses primarily addresses either ongoing losses or the net effect of many pipeline breaks. Regardless of the level of loss, the overall system continues in operation and meets customer needs. In this section, the focus is on short events that fundamentally damage infrastructure and disrupt system operations, including catastrophic loss of function. Examples include flooding of treatment plants, loss of primary water transmission lines, and mass damage of water mains and customer connections in a coastal erosion event (e.g., Hurricane Sandy). Regarding contamination, episodic events such as Harmful Algal Blooms (HABs) caused by cyanobacteria blooms can disrupt treatment facilities.

"Black swan" events[5] do happen. In each case, the timing and severity of such events is not predictable. However, risk assessment combines risk probabilities with potential damages to determine what facilities are of greatest concern in the event of a severe or destabilizing event. The question then is whether to modify the facility to avoid potential damages. If potential damages are high, system modifications could be worthwhile even at relatively low event probabilities. Conversely, the lower the potential damages, the greater the probability of damage must be to justify action. Climate change is predicted and demonstrably has already begun to exacerbate risks from severe weather events.

This kind of event-based risk assessment is a component of overall asset management. However, system resilience often is not directly assessed in general utility asset management efforts, as utilities tend to focus on the potential for "normal" damages such as pump or pipe failure due to aging. These are threats from within and based on the nature of the system – endogenous threats. External (exogenous) threats (e.g., severe weather events, terrorism, construction excavations not related to the utility) are more often addressed through separate efforts such as the New Jersey Hazard Mitigation Plan from the New Jersey Office of Emergency Management. Federal requirements since the 9/11 (2001) terrorist attacks included

[5] A "high-impact event that is difficult to predict under normal circumstances but that in retrospect appears to have been inevitable." Britannica.

a new focus on drinking water treatment plants, reservoir dams and pipelines. The federal American Water Infrastructure Act of 2018 requires utilities to assess natural and man-made risks and update their emergency response plans. In addition, utilities often focus specific attention on well-known weak points of their system, such as major pipelines or treatment plants in flood plains, as shown in the raising of the Bridgewater-Raritan Plant flood wall, which successfully prevented Hurricane Ida flooding. Dam safety requirements are also a routine component of reservoir operations, maintenance, and upgrades.

Open storage of finished drinking water is a special case for system resilience. In general, federal and state policy requires that finished drinking water be stored in closed facilities. A few New Jersey utilities have open storage, which provides considerable storage at low cost but are subject to introduction of pollutants from wildlife, air deposition and, in a few cases, storm runoff. There is a trade-off between storage volume and quality protection, and exogenous events exacerbate the potential for contamination, which would occur at times where the utility customers are already stressed by flooding or other regional events. The Department is working with the utilities which have these sources to identify the best options which balance water supply flexibility with water quality protection and security concerns.

After Superstorm Sandy, DEP reviewed its rules governing the siting, construction, and operation of the State's drinking water systems. Focusing on four major subject areas – Auxiliary Power, Flood Protection, Emergency Management Planning and Preparedness, and Asset Management – staff developed guidance to ensure that future repair, rehabilitation, and construction efforts were conducted "safer, stronger, smarter." That guidance can be viewed at the resources provided below.

- DEP Division of Water Supply & Geoscience Home Page (DEP-DWSG)
- Asset Management Policy Program: Renewing New Jersey's Water Infrastructure web site (DEP Asset Management)
- DWSG Emergency Response and Preparedness web site (Emergency Response & Preparedness)
- Emergency Response Preparedness/Planning Guidance and Best Practices (Guidance pdf)

DEP continues to work with the drinking water sector to assure that it is prepared for extreme weather, dealing with emergencies, and implementing asset management. In addition, DEP continues to work with water purveyors to implement asset management requirements of the Water Quality and Accountability Act, as discussed earlier in this appendix.

It is appropriate for DEP and other state agencies to explore the benefits of providing additional guidance and clarity on expectations for severe weather and incident/event scenarios that should be used in resilience planning, such as riverine flooding, coastal storm surge and erosion, HABs, and compounding problems (e.g., long-term erosion of a river that exposes a transmission line, making it more prone to damage from a catastrophic event). The most appropriate method for developing such guidance would be a compilation of best practices from existing utility practices, national guidelines, etc. Another option is to require a formal risk assessment for a small number of assets that pose the greatest threats if they

fail catastrophically. The third option is to require use of the risk assessment or the Utility Resilience Index approach[6] in the asset management process under the WQAA.

[6] American Water Works Association. 2019. ANSI/AWWA J100-21 – Risk and Resilience Management of Water and Wastewater Systems. https://engage.awwa.org/PersonifyEbusiness/Store/Product-Details/productId/88116441

EMERGENCY AGREEMENTS BETWEEN PURVEYORS

Emergency agreements to provide water are a fundamental response to the potential for temporary system failure (e.g., a well failure or treatment plant issue) or temporary need (e.g., drought). The existing Water Allocation rules at N.J.A.C. 7:19-6.9(g) (Operation of Interconnections) require DEP approval of all such agreements. These reviews are typically reviewed as part of the Emergency Response Plan each system is required to submit and have on file. Each interconnection operation agreement should include the interconnection location, size, conditions for use and hydraulic capacity for both directions under the conditions expected for interconnection use. For those interconnection operation agreements proposing guaranteed bulk sale or routine sale/purchase or guaranteed firm capacity supplement, additional Departmental approval must be obtained through a water contract review application under N.J.A.C. 7:19-7.

WATER SUPPLY SYSTEM INTERCONNECTIONS AND SYSTEM STORAGE REQUIREMENTS

DEP continues to implement the recommendations of the *2008 Statewide Interconnection Study*, including: using existing interconnected water systems to mitigate and avoid the adverse impacts of drought conditions and other water shortages; using the Water Supply Management Decision Support Tool (WSMDT), the New Jersey RiverWare Model and or equivalent tools, to evaluate and, if necessary, facilitate communication and recommended, proactive transfers in cooperation with affected water suppliers between surplus and deficit areas; and ensure that the data are kept current. Recently the Department worked with North Jersey District Water Supply Commission and Veolia Hackensack to modify normal operations of the Wanaque aqueduct. This work resulted in reduced drought risk with minimal impacts to day-to-day operations. For more information on the Interconnection Study and the WSMDST, please refer to: Interconnection Summary.

One issue that deserves further consideration is the relative reliance on internal system resilience, including the ability to store sufficient finished drinking water to meet emergency needs such as system malfunction and emergency needs to off-line water supplies due to finished drinking water quality issues (e.g., Legionnaire disease, contamination of open water storage), versus reliance on interconnections that provide external water supplies during emergency situations. Reliance on interconnections means that the resilience of the sending system should be assessed as well, to ensure that contracts are in place and the sending system can verify availability and provision of water at needed times, even if their system is also undergoing a stressed condition. The value of regional connections between large systems, such as in the Northeast Region (e.g., Passaic to Hackensack, Upper Passaic to Lower Passaic/Hudson County, Raritan to Passaic) in responding to drought conditions also requires assessment of resilience between systems.

With the more recent emphasis on water quality, particularly with regard to lead release since 2016, water purveyors have shown to be more reluctant to make bulk transfers of water outside of emergencies, or routine bulk sales. Ordered bulk transfers during the drought of 2016-2017 were generally disregarded by purveyors in the Northeast.

SURFACE WATER RESERVOIR SYSTEM MODELING

Most reservoir-based water systems have developed safe yield models to determine the amount of water than can be routinely provided during a repeat of the drought of record for that system (usually the 1960s multi-year drought, but a few systems use other droughts as the drought of record as a shorter but more severe rainfall deficit period). Two models have been developed by the New Jersey Water Supply Authority (for the Raritan System, using the RiverWare modeling platform) and the North Jersey District Water Supply Commission (for the Wanaque/Monksville System) to update safe yield estimates. DEP will continue to develop computer models to simulate water availability under a variety of assumptions for regional and inter-regional groups of water systems. One has been developed using RiverWare for the Hackensack/Passaic River Basins and is used in water allocation reviews. An inter-basin model linking the Hackensack/Passaic and Raritan models may be valuable, given the existing and potential interconnections between the two basins. DEP will be expanding the scope of this model to address all surface water systems, including interconnection flow scenarios. The primary goals include improved operations and coordination between systems to manage supplies during normal and emergency conditions.

IMPLEMENTATION OF WATER CONSERVATION AND EMERGENCY PLANS

Pursuant to N.J.A.C. 7:19-6.5(a)3, all water allocation permit holders must submit updated Water Conservation and Drought Management Plans (WCDMP). DEP expects that systems update WCDMP's to ensure that they are accurate and implementable. All water purveyors will implement their WCDMPs as approved by DEP. DEP will enforce the requirements of the existing rules to ensure that drought management and response plans are up to date. The WCDMP's must include:

- voluntary water use restrictions for corresponding stages of drought warning and water emergency, precipitation deficits or reservoir storage deficits;
- voluntary transfers of water via interconnected systems for use when prescribed reservoir storage level thresholds are reached;
- other measures designed to reduce demands, water usage or water loss, or which otherwise have the effect of maximizing water supplies during periods of low precipitation or below-normal water supply storage; and
- for purveyors with reservoirs, rule curves for reservoirs that can be used to establish storage level thresholds that will trigger appropriate actions.

DEP will review and evaluate the efficacy of amending the Water Allocation rules at N.J.A.C. 7:19-2.2(i) to enhance the current water conservation and drought management plan forms with a new water audit and water loss program that is compatible with and capable of incorporating reported results under the Delaware River Basin Commission requirements, inclusive of best management practices and reporting requirements. Water auditing, as discussed previously in this appendix, is a mechanism to provide water suppliers with water system information that helps identify water losses, provides an opportunity to improve efficiency, and ultimately results in cost savings with respect to water pumping, treatment and infrastructure procurement, operation, and maintenance. The audit results will provide DEP with a

uniform, manageable, digital, database of water system information. Ultimately, the audits will provide greater water accountability, reduce water waste, and lead to greater water efficiency.

RESTRUCTURING WATER ALLOCATION REGULATIONS TO ADDRESS DROUGHT MANAGEMENT AND WATER EMERGENCY PROCEDURES

Water supply emergency management procedures should continue to be streamlined to consolidate and reorganize existing rules that direct the management of water supplies, including the prioritization and restriction of water uses, during a water emergency. The Department is considering amendments to the existing rules (NJAC 7:19), which have been readopted without substantiative change since 1990. Amendments to the rules are needed to reflect amendments to the Water Supply Management Act, N.J.S.A. 58:1A-1, enacted in 2002 that related to temporary water allocation permits in Salem and Gloucester Counties; in 2004 related to provisions of the Highlands Water Protection and Planning Act (Highlands Act), N.J.S.A. 13:20; in 2006 exempting the payment of water use registration annual fees for volunteer fire companies pursuant to N.J.S.A. 40A:14-70; and the enactment in 2008 of the Environmental Enforcement Enhancement Act in accordance with N.J.S.A. 58:1A-16d. Other proposed amendments are intended to simplify the water emergency surcharge schedule, modernize and simplify business process, increase flexibility, incorporate stakeholder input and create consistency across Department programs. This includes proposed amendments to address issues recognized after the 2002 drought emergency. A number of problems with the existing rule have been identified, which inhibit the Department and permittees to efficiently and effectively respond during drought emergencies.

One of the issues recognized in past drought declarations is the need to reduce purveyor minimum passing flows prior to declaring a drought warning. Current rules permit passing flow reductions to occur under a drought warning declaration. Generally, by the time a drought warning is declared, stream flows are low enough that reductions do not provide a significant net gain in storage as it would if the passing flows could be reduced earlier when stream flows are higher. The ability to reduce minimum passing flows during drought watch would keep more water in storage when flows are higher and could mitigate the need to declare a drought warning.

DISCONTINUATION OF GENERAL "OVERDRAFT" PROVISIONS

DEP assesses the impact of seasonal variations in water use so that any overdraft provisions in water purchase contracts are supported by the safe yield of the source waters being impacted. If water purveyors need seasonal water or overdraft provisions they should be supported by both safe yield models and guaranteed contracts between water purveyors. DEP will consult with water supply purveyors to make sure that this is done in such a way as to not adversely impact the ability of those purveyors to meet demands.

WATER QUALITY ACCOUNTABILITY ACT

DEP works with water supply purveyors to ensure they have proper financial and technical assistance in meeting the requirements of the Water Quality Accountability Act (WQAA). DEP has developed or helped develop appropriate standards and check lists with the Department of Community Affairs and the Board of Public Utilities to achieve the goals of the Act. To simplify compliance with the WQAA, DEP developed an online portal for submittal of all required information using standardized forms; this approach also makes it possible for DEP to then provide the results for public review and to conduct statistical analyses of the data.

The New Jersey Environmental Infrastructure Financing Program (NJEIFP) is a joint effort of DEP's State Revolving Fund (referred to here as DWSRF), the New Jersey Infrastructure Bank, and additional funds as appropriated by the Legislature, including federal funds such as the Infrastructure Investment and Jobs Act of 2021 (Bipartisan Infrastructure Law), the Disaster Relief Appropriations Act for Hurricane Sandy (2013), and the American Recovery & Reinvestment Act of 2009. DWSRF and associated funding is made available in conformance with the Intended Use Plan adopted each year by DEP (see DWSG Loans and Capacity Development).

AFFORDABILITY AND PCWS RESILIENCE

Good planning is only as valuable as the implementation that follows, and all implementation requires funding. In some cases, capital projects may reduce operation, maintenance and rehabilitation costs, offsetting some or all of the capital costs. However, in many cases, rates will need to rise to provide sufficient revenue for effective O&M and asset management, including both structural and personnel assets. As a result, customers will be required to increase their payments, which can be financially stressful for lower-income households and businesses. The USEPA has used affordability as a factor in determining whether a utility has a sufficient financial capacity to meet drinking water and wastewater requirements, but their guidance is not focused on customer affordability per se. National and New Jersey evidence shows that drinking water and sewer (water) utility costs have been rising for decades in response to regulatory requirements and asset management needs.

There is an extensive literature on the affordability of costs for water utilities, but no national consensus yet exists on the best approach or whether a "best approach" can even be defined. However, there is growing consensus that use of median household incomes (in line with 1990s USEPA guidance on utility financial capacity) is not appropriate, as household financial stress is more likely at lower income levels, such as the 20th percentile income (aka Lowest Quintile Income). These issues are discussed in two reports that provide the only New Jersey-specific evaluation of household financial stress from a combination of drinking water and sewer utility costs relative to 20th percentile income (Van Abs and Evans, 2018, Van Abs, et al., 2021). The latter report estimated that roughly 20 percent of New Jersey household have water utility costs that exceed a baseline affordability threshold, assuming that all households directly pay their water utility bills (recognizing that some pay indirectly through rents or are subsidized through affordable housing programs). These households are concentrated in historic urban areas, as expected, but also are common in inner ring suburbs, more recent suburban areas, and some rural town centers.

For this reason, affordability will be an ongoing concern in many areas of New Jersey, potentially harming the resilience of drinking water utilities that face strong opposition to rate increases despite their asset management and improvement needs. High inflation rates which occurred over the last several years need to be considered in future cost analyses as well.

INTERCONNECTIONS, CONJUNCTIVE USE AND MANAGED AQUIFER RECHARGE

PCWS in New Jersey range from very small, isolated systems serving individual developments or buildings to very large systems serving nearly 1 million people. Many of the smallest systems serve residential developments that use septic systems or other discharges to groundwater, and therefore have a limited impact on water availability. However, the medium and large systems have larger withdrawals or rely on other water purveyors for bulk purchases of treated drinking water; they often are in areas with sewer systems, which can result in significant depletive and consumptive water demands. These systems may also face more significant drought impacts. Several approaches can reduce the sensitivity of these systems to drought or seasonal shortages.

WATER SUPPLY SYSTEM INTERCONNECTIONS

One approach to offset supply risk is to interconnect with other systems for routine or seasonal water supplies to optimize the use of regional water resources (separate from emergency transfer issues). Many systems in the more densely populated areas are interconnected with neighboring systems and transfer water on a regular or emergency basis. Interconnections and bulk purchase contracts are reviewed by DEP. Interconnections add to overall reliability and resiliency. It is important that the quality of the transferred water not be detrimental to the receiving system and that the sending system's resilience is not diminished by the transfers. DEP will work with purveyors make sure any such problems are prevented or minimized. See discussion of Interconnection Study and WSMDST above under Water System Resilience, above.

CONJUNCTIVE USE OF MULTIPLE WATER SUPPLY SOURCES

Conjunctive use refers to the coordinated utilization of multiple water supply sources to maximize the sustainability of the overall resource. One example is where a system diverts water from an unconfined aquifer at times of high availability and then relies on confined aquifers when water use, temperatures and sparse precipitation could more adversely affect surface water resources. Another example is the use of "run of the river" withdrawals during higher flows, and then shifting to reservoir supplies in times of low flows. In New Jersey, where few sites remain for additional conventional water supplies (e.g., new reservoirs sites, untapped rivers, unused aquifers), conjunctive use offers significant potential to extract the most use from available supplies for some but not all systems. Conjunctive use can strategically improve overall water supply reliability by providing a range of sources that can be systematically employed and rested on a seasonal basis, during drought or other water shortages, or used to reduce the strain from peak demands that otherwise might occur on a single water supply source. Conjunctive use alternatives operated in tandem with other strategic options such as water conservation, RWBR, aquifer storage and recovery, and non-depletive water/wastewater systems, can extend available water supplies and avoid or minimize the adverse effects of drought, while minimizing environmental impacts.

Conjunctive use traditionally has been implemented in areas of the country where surface water is the predominant source of supply, and groundwater is held in reserve for use during the dry season or periods of severe drought. While this type of conjunctive use has potential application in New Jersey,

there are other forms, including the combined use of various surface water and confined and unconfined groundwater sources.

While aquifers afford a natural "underground reservoir" storage capacity, New Jersey's aquifers are vulnerable to saltwater intrusion in certain locations and excessive withdrawals from unconfined aquifers may significantly deplete base flow leading to stream flow impacts. Integrated seasonal use of both confined and unconfined aquifer types, combined with optimized diversion points, may mitigate adverse resource impacts by redistributing and reducing overall demand on each aquifer. Withdrawals from unconfined systems can be limited by employing minimum passing flows that take into consideration current and projected withdrawal effects and are protective of downstream users and uses.

MANAGED AQUIFER RECHARGE

There is established benefit and continued interest in using confined aquifers as storage reservoirs to provide water stored during off-peak periods to meet peak demands. Managed Aquifer Recharge (MAR) is the process of pumping excess allocation waters into an underlying aquifer for storage and future recovery. This may be more commonly known as Aquifer Storage & Recovery (ASR), but DEP prefers the term MAR as it more broadly covers the multiple operational permutations that may go into these types of projects, of which one is ASR. While the injected water is treated to meet the drinking water Maximum Contaminant Levels (MCLs), revised review procedures were developed to ensure compliance with the Ground Water Quality Standards, N.J.A.C. 7:9C (GWQS). The Division of Water Quality (DWQ) in coordination with the Division of Water Supply and Geoscience (DWSG) developed comprehensive review procedures for MAR projects with the goal of safeguarding the drinking water supply, while maintaining compliance with the Safe Drinking Water Act and protecting ground water quality by ensuring compliance with the GWQS

As of May 2023, there were 20 approved MAR wells in 16 DEPS permits in the state of New Jersey. Nine (9) of the MAR operations are considered permit-by-rule (PBR), meaning no New Jersey Pollutant Discharge Elimination System (NJPDES) Discharge to Ground Water (DGW) permit was previously issued for the operation. The DWQ is currently in the process of obtaining additional information from these 9 entities to properly regulate and monitor these operations through issuance of an individual NJPDES DGW permit. This additional requested information includes, but is not limited to, pollutant characterization scans of the underlying aquifer water quality and the injectate water quality to review compliance with the GWQS. Scans for pollutants of emerging concern are also being required under the updated review procedures. This additional information will aid the facility in better understanding their system and will facilitate consistent permitting for all MAR operations.

The *2008 Statewide Interconnection Study* recommended that DEP continue to promote MAR and multi-year water storage or "banking". This technology provides drought management through the transfer of demand from year to year, storage during wet years and recovery in dry years. The viability of MAR is contingent upon the geology of an area and the ability to use the wells without interference to other aquifer users. MAR wells can be used to manage saltwater intrusion in Areas of Critical Water Supply Concern as well as in Cape May County.

MAR is a water supply management alternative that has been effectively used by water purveyors in New Jersey since the last century. Sites are typically located on the Atlantic coast where supplies are limited, and summer demands can be very high. It is often used to meet seasonal demands and to prevent saltwater intrusion. MAR is a very valuable water supply management tool and will continue to be utilized and supported by the Department where appropriate.

WATER SOURCE SUBSTITUTION

Water users generally rely on water supplies that are appropriate for their needs. Households, office buildings and commercial facilities rely on public water supply systems (ground or surface water supplies, treated) or self-supplied wells (mostly untreated). Agriculture, golf courses and mining rely primarily on untreated water from surface waters or shallow groundwater systems. Manufacturing facilities may use water either from public water systems or local raw water resources, but in either case they will often pre-treat the water to match manufacturing specifications. Electric power generation facilities will typically use local surface waters, also pre-treated to reduce fouling of the power plant and cooling facilities. Each of these uses places some level of stress on the natural water supplies. Water use efficiency and water conservation reduce these stresses. However, in certain circumstances, a shift in water source can reduce an existing stress. There are several key factors in water source substitution. First is to ensure that the substitution does not cause its own problems. For example, shifting from an unstressed supply to a stressed supply is inappropriate even if less expensive to the user. Regarding Reclaimed Water for Beneficial Reuse, or RWBR, wastewater treatment plant discharges to freshwaters are important to streamflow, and reduction of that discharge through diversion to beneficial reuse would harm aquatic ecosystems. Conversely, RWBR is a net positive for any wastewater discharge to ocean waters. It is important to note that RWBR is distinct from historic indirect reuse, such as when wastewater effluent is discharged to a river and subsequently withdrawn for a new use downstream. That process is common in rivers across the country, and especially relevant in the Passaic River Basin.

Second, costs often limit water source substitution. Major water source substitutions may require new facilities, such as the Manasquan Reservoir (Water Supply Critical Area #1) and the New Jersey American Delran Intake (Water Supply Critical Area #2). RWBR requires a means of transporting the treated effluent to its users, which may be expensive. For street sweeping and sewer jetting, the cost will be lower for areas close to a wastewater treatment plant, but higher for a longer trip. For RWBR to golf courses and industry, pipeline costs will be a major factor. And, if additional treatment is necessary prior to reuse (e.g., for food crop agricultural purposes), that additional treatment cost can make a project nonviable.

One option is to improve the planning process to identify water sources and public water systems that face stresses amenable to water source substitution and RWBR, and also to identify wastewater treatment plants where loss of discharge flow would not cause harm to downstream resources (e.g., ocean discharges). The planning process would then identify opportunities for effective water source substitution as well as regulatory changes that might be needed.

A second option is to identify public water systems, especially smaller systems with their own water sources, that are most at risk for contamination that makes their existing supply financially nonviable, and identify opportunities for water source substitution, including interconnections, that would be cost-effective.

A third option is to assess changes to New Jersey laws and building codes that would reduce barriers to beneficial reuse of stormwater and wastewater within a project's boundaries (as with Battery Park City in New York City), with appropriate consideration to long-term maintenance and management of the facilities.

POTENTIAL NEW AND EXPANDED SOURCES OF SUPPLY

As discussed in Chapter 4 and in more detail in Chapter 6, some water supply resources in New Jersey are showing confirmed or possible current or future stresses where existing or future water withdrawals may harm stream ecosystems or exacerbate saltwater intrusion, if not managed. The DEP Water Allocation program is responsible for ensuring that water allocation permits protect other water users and the integrity of water resources. Through past planning efforts, some capital projects have been identified as potential future water supply resources. Most are not needed immediately but hold potential for meeting future needs.

NORTHEAST DROUGHT REGION

VIRGINIA STREET INTERCONNECTION/PUMP STATION

As identified in the 2008 *Statewide Water Supply Interconnection Study*, one opportunity for inter-basin transfers involves the following systems: The City of Newark, New Jersey American Water (NJAW) – Raritan system, and the North Jersey District Water Supply Commission (NJDWSC). The pivotal asset to effectuate meaningful transfers between these three systems is the Virginia Street Interconnection/Pumping Station, which is located in Newark and was constructed in the early 1980s using 1981 Water Supply Bond Fund monies.

The Virginia Street Interconnection/Pump Station was constructed over 35 years ago and is currently limited in size; in addition, limited resources have been devoted to operation and maintenance. The primary question is how to distribute costs for a facility that involves multiple parties, each with their own systems, but could be critical to Northeast water systems during droughts. DEP will work with key Central and Northeast drought region water suppliers to develop a strategy for enhancements to the Virginia Street Interconnection/Pump Station and related appurtenances so that it is fully functional and automated. However, the Raritan System has ample remaining safe yield for normal purposes, and so Passaic to Raritan transfers would be for limited periods only.

The *2008 Interconnection Study* identified the Virginia Street Interconnection as a critical water supply asset and acknowledged the potential benefits of providing routine water transfers between drought regions. By transferring 10 mgd between the Central Drought Region (NJAW-Raritan system) and the Northeast Drought Region via Virginia Street, it might be possible to significantly reduce the occurrence, duration and severity of water shortages in the Northeast Drought Region. The investigation indicated that if the 10 mgd routine transfers had been implemented between 1990 and 2003, the number of days that NJDWSC's reservoir storage was below the drought warning curve would have been greatly reduced, if all other factors had remained the same.

The Virginia Street interconnection was constructed with a potential design capacity of 30–35 mgd. Two major factors limit the interconnection from realizing its full design capacity. Transmission improvements are needed in the NJAW - Raritan and Newark systems, and a new pumping station is needed at the Belleville Reservoir site. DEP will work with purveyors to evaluate the utility of these improvements to strengthen the Northeast Drought region.

ADDITIONAL INTERCONNECTION OPTIONS

DEP analysis after the 2008 Interconnection Study has shown that additional enhancements and/or expansions to critical water supply infrastructure in the Passaic and Hackensack basins also greatly increase the region’s ability to address water supply emergency conditions including drought and infrastructure repair. These projects work in conjunction with the Virginia Street project to greatly improve the resiliency of the region. These projects include, but are not necessarily limited to, expansion of the Chittenden Road interconnection to include North Jersey District and preservation of the full operational capacity of Newark’s Cedar Grove Reservoir that meets EPA and DEP’s uncovered finished water reservoir safe drinking water requirements. Expanded or additional finished water interconnections in this region as well as any highly interconnected region within New Jersey can greatly increase that region’s or water system’s ability to meet drought or emergency water needs.

Another example of optimizing existing system assets is the interconnected distribution networks of the NJAW's Raritan and Passaic systems and the Northeast region. Part of the NJAW Passaic system demand is met with water from the NJAW Raritan system. Modeling shows benefits of strengthening the connections between these two regions. The NJAW Passaic system has an average demand of less than 40 mgd, approximately 30 mgd of which is met with supplies from the Northeast Region. If the demand of the NJAW Passaic system could be met through additional water transfers from the Central Region, potentially 30 mgd of supply could be made available to meet demands in other parts of the Northeast region. Further detailed investigation is necessary to determine the feasibility of this option.

CENTRAL DROUGHT REGION

The 1981 Water Supply Bond Fund provided $350 Million to support loans for State or local projects to rehabilitate or repair water supply facilities and to plan, design, acquire and construct various State water supply facilities. To be eligible for funding under the 1981 Water Supply Bond Fund, projects or studies must be included in the NJSWSP.

The 1996 NJSWSP and the Eastern Raritan Basin Water Feasibility Study identified several projects in the Raritan River Basin that could be used to increase the safe yield of the New Jersey Water Supply Authority (NJWSA) within the Raritan Basin and Central Drought Region. In addition, these projects could potentially increase the firm capacity of certain water systems in the Northeast and Coastal North Drought Regions through inter-basin transfers from the Raritan Basin, as the NJWSA Raritan System as of early 2023 has 59 mgd of safe yield (of 241 mgd total) that has not been contracted for sale to water systems within the Raritan region. DEP will continue to work with the NJWSA and others to develop and prioritize preliminary steps, set timetables for action, and identify appropriate funding source(s) for projects in this region.

These steps include preparation of background information for major permitting decisions, verification or acquisition of easements or property, the identification of coincident infrastructure needs, and evaluation of and preparation for potential legal issues.

KINGSTON QUARRY RESERVOIR

This project was proposed by Trap Rock Industries, Inc. as the eventual reclamation plan for their rock quarry when operations cease. It was studied in the Eastern Raritan Basin Water Feasibility Study and incorporated into the 1996 and 2017-2022 NJSWSPs. The quarry is located in Franklin Township, Somerset County, directly adjacent to the Delaware and Raritan Canal and Millstone River. At completion, it is anticipated to have two large areas that extend well below the Canal level, providing an opportunity to store unused Delaware and Raritan flows and high flows from the Millstone River for release during low-flow periods. Water diversions from these sources will flow by gravity into the reservoir and water storage releases will be pumped back to the Delaware and Raritan Canal. This project is a viable option only if legal issues pertaining to land, operation, and necessary storage volumes are satisfied at the required time of transference. With nearly one-quarter of NJWSA Raritan System safe yield still available, increased conservation and changing population projections, it is still uncertain as to when the increased safe yield will be needed.

The Kingston Quarry Project has been shown to be the most cost effective of the projects. However, due to quarrying rates as of 2023, the quarry is still actively being used, and it is unclear when it might be available for use for water supply. DEP and NJWSA will consider engaging a consultant to research the next steps required to pursue the Kingston Quarry Reservoir Project. These key aspects of this investigation, as identified in the Eastern Raritan Basin Water Feasibility Study, should include:

- legal terms turning the site over to State ownership;
- a guaranteed schedule for State acquisition; and
- a guaranteed rate of rock removal sufficient to provide the necessary water storage volume at the required date.

The capital cost for the Kingston Quarry Reservoir project was estimated to be $102 million for engineering and construction as of 2015. The project could be broken down into two phases. Phase 1 would provide for storage of 7.2 billion gallons at a cost of $51 million. Phase 2 would provide another 7 billion gallons of storage at an additional cost of $51 million.

The above two projects have the potential to provide over 100 mgd of additional water supply to address future development needs and/or offset existing or projected deficits. If the 20 mgd of New Jersey's originally approved 100 mgd allotment under the 1954 Supreme Court is re-established permanently to the Delaware & Raritan Canal, (discussed in detail in Delaware River Basin Commission section in Chapter 5), the total additional safe yield is estimated to be 120 mgd.

In addition to the Kingston Quarry Project, DEP is open to the possibility of any additional quarries located near surface-water sources which may be suitable for use as a water supply reservoir. For example, there are several quarries near the Delaware and Raritan Canal which might be suitable at some time in the future. However, any such action depends on the quarry reaching the end of its useful life, and the volume of potential storage sufficient to justify the cost of required infrastructure.

CONFLUENCE PUMPING STATION

This project would be located where the North Branch and the South Branch of the Raritan meet to form the mainstem of the Raritan River at the boundaries of Branchburg, Bridgewater, and Hillsborough Townships in Somerset County. As indicated in the 1996 Plan and the Eastern Raritan Basin Water Feasibility Study, there has always been an assumption that the Confluence Pump Station Project would be the first of the major capital improvement projects to be completed if additional safe yield is needed in the NJWSA Raritan System.

The existing release pipeline from Round Valley Reservoir to the South Branch of the Raritan River can presently be used for releases from Round Valley, but is proposed to be replaced to facilitate pumping, under pressure, into Round Valley Reservoir from the Confluence Project. The 2015 capital cost estimate for the Confluence Project is $150 million for engineering and construction of a 200 mgd intake/pump station site at the confluence of the North and South Branches of the Raritan River and a 12-mile long 96”–108” diameter force main to Round Valley Reservoir, which will allow for pumping into and release from the reservoir. This project would increase the safe yield of the Raritan Basin by 46 mgd.

The project can be accomplished in two phases. Phase 1 calls for the replacement of 3.4 miles, 108” diameter release pipeline at a project cost of $40 million. There are no issues with respect to easements because the pipeline will be replaced along the existing corridor. Phase 2 calls for the construction of a confluence pump station and installation of 7 miles of new 96” - 108” diameter pipe between the confluence of the North Branch and South Branch Raritan River and the existing release structure in Whitehouse Station at the terminus of the existing release pipeline a project cost of $173 million (in 2017 dollars). Earlier efforts to acquire the easements for the Confluence Pump Station Project pipeline resulted in some gaps along the proposed route. In addition, there has been some encroachment on acquired easements.

The final issue is how the introduction of water from the confluence would affect water quality of Round Valley Reservoir, which currently receives water only from the South Branch Raritan River, through the Hamden pumping station. Round Valley Reservoir has been designated Category One (C1), such that no reduction in water quality is allowed. For these reasons, the Kingston Quarry project may involve fewer issues regarding water quality and would not entail creation of a new pipeline, reducing issues of property acquisition. The confluence project is currently not being actively pursued but is a potential project for the future.

MULTI-DAY PASSING FLOW AVERAGING

The New Jersey Water Supply Authority was created by New Jersey Statute NJSA 58:1B-1 et seq. and the Raritan System passing flows are also defined in the same statute. This is atypical in New Jersey as most of the other passing flows are defined in Water Allocation permits. The statute states:

> *“8. a. Whenever the flow of water in the south branch of the Raritan river is less than 40 million gallons daily at the United States Geological Survey stream gauging station at Stanton, or less than 70 million gallons daily at the United States Geological Survey stream gauging station at Manville, or less than 90 million gallons daily at the United States Geological Survey stream gauging station at*

> *Bound Brook, a sufficient amount of water shall be released from the Spruce Run reservoir, or from the Round Valley reservoir or any other reservoir or reservoirs as may be constructed on the Raritan river or its tributaries, and from the Round Valley reservoir in the amounts as will maintain not less than the aforementioned flows of 40 million gallons daily at Stanton and 70 million gallons daily at Manville and 90 million gallons daily at Bound Brook…"*

The statute also states that:

> *"b. The commissioner is authorized to alter the passing flow requirements set forth in subsection a. of this section as necessary to ensure the protection of the public health, safety or welfare, or the protection of the environment."*

In order to meet the passing flow requirements, reservoirs releases are made anywhere from 24 to 72 hours in advance. Releasing too much water wastes storage which might be needed later in a water supply emergency. Releasing too little water results in a violation and can negatively impact downstream ecology and water users. Predicting the precise amount of water to release requires perfect weather and hydrologic forecasting skills- which is problematic at best. Accurate releases require accurate weather forecasts and specifically accurate rainfall-runoff forecasts and river travel time estimates- all of which are highly variable and dependent on antecedent conditions in the watershed. These forecasts are inherently imprecise and in order to prevent a miss of the passing flow, the Authority ends of releasing too much water. Initial assessments suggest that a multi-day averaged passing flow scheme would allow the Authority to reduce over releases, because they would have additional time to balance out an under release over the next several days. More efficient use of stored water results in increased water supply and system resiliency and decreased costs to customers. Additional work is required to quantify appropriate flow ranges that are protective of instream ecology and downstream users and multi-day averaging length, and statutory changes may be needed.

Most reservoir passing flow requirements in the state are immediately downstream of reservoirs so forecast inaccuracy is not a major problem, however if there are other systems that would benefit from this passing flow method it should be considered for them as well.

WATER TRANSFERS FROM CENTRAL TO COASTAL NORTH DROUGHT REGIONS

Bolstering the interconnection of water supply systems between the Central (Raritan River Basin) with Coastal North Drought Regions systems has long been considered a key State drought management objective. Critical Water Supply Concern No. 1 encompasses most of the Coastal North Drought Region and limits the amount of groundwater available for withdrawal. Continuation of the construction of the third and final phase of Middlesex Water Company's (MW) South River Basin Pipeline, as identified in the South River Basin Water Supply Study for Critical Area No. 1, will provide for both routine and emergency water transfers between the two drought regions, but will be instrumental in averting and mitigating drought/emergency impacts for the Coastal North Region.

This interconnection could also support future targeted growth in Middlesex, Monmouth, and Ocean Counties and provide resiliency for the area. For more information on system interconnections and transfers in the Central and Coastal North Drought Regions, see the Statewide Water Supply

Interconnection Study referenced above. The existing pipeline system (two of three total sections), completed in 1992, is estimated to be able to provide an average day demand of 16.5 mgd from Middlesex Water to purveyors in the South River Basin area in southern Middlesex County and northern Monmouth County. The proposed final phase of the pipeline can be designed to transfer a cumulative supply of 30-40 mgd through the entire South River Basin Transmission pipeline depending on availability of supplies. While growth projections suggest that construction of the interconnection is not yet needed, DEP recommends that Middlesex Water and all involved water supplies work with DEP to continue discussions to develop a plan for completing the interconnection when projected demands indicate a need for additional water, and for improved resiliency between regions.

RETENTION OF PREVIOUSLY ACQUIRED WATER SUPPLY PROPERTIES

While they do not presently figure in near-term capital water supply development, DEP will ensure the following properties remain preserved for future water supply purposes:

SIX MILE RUN RESERVOIR

The Six Mile Run Reservoir site is located in Franklin Township, Somerset County. The 3000-acre reservoir site would be situated on a tributary to the Millstone River and would store excess flow from the Millstone River and unused allocation from the Delaware and Raritan (D&R) Canal. Water would be used for low-flow augmentation of the Millstone and D&R Canal. This project was identified as the third most cost-effective project in the Eastern Raritan Water Feasibility Study (after the Kingston Quarry and Confluence Pumping Station), and will remain on the list of potential water supply projects. Except for a few smaller properties, the entire site has been purchased and is managed as a passive recreational resource by DEP State Park Service. The DEP will work with the NJWSA to complete the acquisition of all property that would be in the pool elevation of the proposed Six Mile Run Reservoir.

HACKETTSTOWN RESERVOIR

The Hackettstown Reservoir was identified in the 1982 NJSWSP as a means of augmenting Delaware River flow during periods of low precipitation in order to meet New Jersey's intra-state regional requirements with the Delaware River Basin Commission. The 1996 Plan stated that these reservoir properties should be preserved as a potential water supply facility in this region. The Hackettstown MUA states, however, that a portion of the property which would have held the reservoir has been sold to private parties. Another portion is part of Allamuchy State Park. As part of this Plan the reservoir is retained on the list of potential projects even though its future development has multiple technical and geologic hurdles that needs to be addressed.

ADVANCED TREATMENT TECHNOLOGIES

Sources of supply can also be developed through the application of advanced treatment technologies. In addition to the implementation of RWBR as a source of supply for existing and new non-potable purposes, the DEP will continue to assess and support proven treatment technologies to convert "non-potable" sources of supply to "potable sources." For example, Cape May is a peninsula surrounded by salt water. Water withdrawals from the confined Cohansey and Atlantic City 800-foot sand aquifers have lowered water levels and caused the intrusion of salt water inland. Supply wells in Wildwood, Cape May

City, and Lower Township have already been abandoned due to saltwater intrusion. The Cape May City Water Department has reduced withdrawals from its confined Cohansey aquifer well field due to saltwater intrusion and now employs a desalination plant to treat brackish water withdrawn from the Atlantic City 800-foot sand. Keansburg Borough, Monmouth County also began using desalination in 2012. Other water systems within the Coastal Plain are also considering the expanded use of this technology and management options.

In addition, as discussed in Chapter 2, some existing water supply resources have been or may soon be contaminated by substances that are difficult or costly to treat. Where a water system may determine that continued use of that water resource is currently not cost-effective, improvements in technology could result in continued or resumed use of the water resource.

The continued and possibly expanded use of desalination, advanced treatment, reuse, ASR and conjunctive use will be considered as part of the multifaceted solution to long-term water supply needs in that region. DEP will continue to consider these technologies, within the context of sustainable energy use and waste disposal in order to address New Jersey's water supply needs.

OTHER ACTIONS TO USE WATER EFFICIENCY AND REDUCE IMPACTS

NEW OR INCREASED ALLOCATIONS FOR HIGHLY CONSUMPTIVE NON-POTABLE USES

Decisions to allow for new or increased water allocations and water use registrations for highly consumptive, non-potable uses (with some exceptions for remedial activities, dewatering activities, emergency backup for RWBR diversions, or when the RWBR supply is unavailable) provide that potable supplies would be preserved for potable purposes where appropriate, and RWBR would be encouraged for non-potable purposes. Such policies only apply to those entities regulated under N.J.A.C. 7:19, and not to agricultural diverters regulated under N.J.A.C. 7:20A.

ASSESSING AGRICULTURAL WATER USE AND ANTICIPATED FUTURE DEMANDS

One water supply management challenge in New Jersey is balancing the competing uses of our water supply (e.g., drinking water, agriculture, industry and commercial activities, and water-dependent species habitat) and ensuring the sustainability of this vital resource. Addressing current and projected agricultural water supply needs has always been a key component in striking that "balance."

The agricultural community, including aquaculture, contributes significantly to the economy and culture of the "Garden State." According to a Northeast Economic Engine report released by Farm Credit East in 2020,[7] New Jersey's agriculture which includes fresh fruits and vegetables, feed crops, livestock, greenhouse and nursey has a $13.6 billion impact on the State's economic output. Agriculture is also a key component in maintaining open spaces that provide aesthetic, historical and environmental benefits to the State, including habitat and groundwater recharge. However, many of New Jersey's highest-value

[7] Northeast Economic Engine: Agriculture, Forest Products and Commercial Fishing, accessed May 8, 2023 from Farm Credit East Knowledge Exchange

agricultural crops rely extensively on highly consumptive irrigation; in fact, the USGS estimates that approximately 90% of agricultural irrigation is lost to evapotranspiration (Nawyn, 1997). Improved irrigation techniques and use of reclaimed water for non-edible crops can improve water use efficiency.

The Agriculture, Aquaculture, and Horticulture Water Usage Certification (Ag Cert) rules (N.J.A.C. 7:20A) govern water usage by the agricultural community. Under these rules, certification holders are required to submit annually, a record of the amount of water withdrawn each month. DEP reviews usage reports to determine if they are consistent with the irrigated acreage and previously reported totals. However, since most of the agricultural diversions are not metered, it is difficult to determine if reported actual diversion rates are consistent. Requests for new or increased agricultural certifications will require the implementation of best management practices to reduce consumptive losses. Renewals of previously approved, but currently unused allocations for agriculture are required to justify the need through Agricultural Development Plans, as required under N.J.A.C. 7:20A-2.4(d).

Based upon the last five years of agricultural use data reported to DEP through 2020, agricultural users are using only about 25% of their annual allocation. The results of the surface water and unconfined groundwater availability assessment (see Chapter 4 and Appendix A) indicates water withdrawals would exceed water availability at full allocation in 90 of the 151 onshore HUC11 watersheds; 28 of these would have agriculture as the major source of diversion. In many instances the results of the unconfined groundwater availability assessment may reveal a more accurate, less stressed condition if the approved allocations for agricultural uses more realistically matched the actual quantity used. Further efforts between the DEP, the State Agriculture Development Committee, the Department of Agriculture, Rutgers Agricultural Agents and other agriculture stakeholders can help obtain a solution for gathering better agricultural water use data, building on the pilot project discussed in Section B, above.

A USGS funded study conducted by DEP installed meters on 10 existing agricultural diversions. The metered results were then compared to the reported estimates. Results showed that metered results were significantly different than the estimates which are currently required under the Agricultural Certification requirements. Of note, was the observation that larger diversions, approximately greater than 2 million gallons per month, were statistically different than the reported value and almost always with the reported value greater than the estimated value. This has ramifications for planning and modeling in regions where agriculture water use is large.

DIVERSION IMPACTS TO WETLANDS

Water diversions, located outside of wetlands and transition areas, and therefore outside the jurisdictional area of the Freshwater Wetlands Protection Act (N.J.S.A. 13:9B), have the potential to adversely affect groundwater dependent threatened and endangered species habitat through drawdown of groundwater levels. However, the cooperative review of impacts to wetland impacts by the Divisions of Water Supply & Geoscience (DWSG) and of Land Use Regulation (now Watershed and Land Management) ceased following a 2009 decision, In Re Agricultural, Aquaculture and Horticultural Water Usage Certification Rules, N.J.A.C. 7:20A-1.1 et seq. that held that agricultural impacts to wetlands should not be regulated under the Water Supply Management Act, but rather should be regulated pursuant to the Freshwater Wetlands Protection Act (FWPA). However, as noted above, the actual drawdown that

impacts wetland habitat often originates (e.g., a pumping well) outside of the jurisdictional limits of the FWPA. Such diversions are known to impact the hydrology and therefore vegetation and habitat value of the wetlands. Consistent with Federal law, DWSG continues to review impacts to Federally Threatened or Endangered species habitat as part of the standard review for new or modified permits in accordance with N.J.A.C. 7:19-2.2 et seq.

DWSG is reviewing its legal authority to proceed using the protocol for the review of wetland impacts used prior to 2009, which was already focused on endangered and threatened species habitat coincident with wetlands. These habitats are in need of protection because the species they support cannot easily sustain habitat degradation resulting from alterations to the hydrology. The review of these impacts is equivalent to the existing review of instream impacts to surface waters that occurs for the protection of aquatic species. The review of impacts to wetland habitats is not only supported by the above-referenced statutes and cases but also by the Water Supply Management Act itself, at N.J.S.A. 58:1A-2, where Legislature finds that DEP must manage the water supply in order to, among other things, protect natural environment of the waterways.

ADEQUATE ASSET MANAGEMENT

ESTIMATING INFRASTRUCTURE NEEDS

The USEPA released the *Clean Water and Drinking Water Gap Analysis Report* in 2002 which estimated the funding gap between projected infrastructure needs and projected infrastructure spending for the water industry nationwide. The Gap Analysis sought to develop a solid basis for understanding the magnitude of the national funding deficit for both water system capital infrastructure and operations and maintenance. For drinking water, a $102 billion ($5 billion per year) gap was identified for capital infrastructure projects, while the gap for operation and maintenance was estimated at $161 billion ($8 billion per year).

In further support of the *Gap Analysis Report* results, the American Society of Civil Engineers New Jersey Chapter released its "*2016 Report Card*" for New Jersey infrastructure, which included a "C" (mediocre) grade for drinking water (see New Jersey Infrastructure Report Card and New Jersey Infrastructure Report Card Summary). In April 2023, the United States Environmental Protection Agency (EPA) estimated in its 7th Drinking Water Infrastructure Needs Inventory that $12.23 billion in capital investments are needed over the next 20 years to install, upgrade, and replace New Jersey's drinking water infrastructure. These estimated needs are based on a national statistical survey of large, medium and small community water systems, in collaboration with state agencies and others. For the first time, information on lead service lines is included in the survey. USEPA reports that this inventory is the most detailed in several inventory cycles, representing a robust analysis of needs by state and nationally. While the Water Quality Accountability Act will provide additional needs information, the USEPA report provides a solid foundation for identified needs at this time. What it can’t necessarily achieve is an accounting of needs that have not been identified but will be through in the coming years through improved assessment management planning.

MAINTAINING INFRASTRUCTURE

Beginning in 2008, the New Jersey Clean Water Council (CWC) conducted public hearings focused on water-related environmental infrastructure (including drinking water), regarding objectives, needs, financing, and management in the State. A recurring theme was the need for greater attention on asset management, including adequately funding related assets on a sustainable basis.

Through the hearing process, many of the most pressing water infrastructure financing issues were discussed with stakeholders and the information gathered were used to provide recommendations to DEP and BPU/DCA (on the cost), such as:

- the elimination of disincentives for proper infrastructure management;
- a mandate for proper asset management;
- full cost pricing of delivered water; and
- municipal assistance.

In response, DEP developed asset management guidance consisting of the following elements: (a) a means of routine asset condition assessment; (b) a programmed and preventive maintenance system; and (c) a procedure for evaluating the life-cycle cost impacts of repair or replacement decisions. The Jersey Water Works collaborative (including USEPA and DEP as ex officio partners) engaged in further analysis of these issues. Subsequently, the legislature approved the Water Quality Accountability Act as one critical response to the need for improved management, as discussed earlier in this appendix.

DEP ASSET MANAGEMENT POLICY PROGRAM

In addition to the implementation of the Water Quality Accountability Act, DEP promotes responsible asset management and adequate infrastructure reinvestment, which are universally accepted practices essential to ensuring the long-term integrity of water system assets and the sustainable supply of safe drinking water to customers.

Water system asset management entails proactively managing infrastructure elements to minimize the total cost of ownership and operation (i.e., life cycle costs) while continuously delivering the desired level of service to customers. Asset management is implemented through a program that continuously evaluates the condition and expected life cycle of system assets in order to establish a maintenance/rehabilitation/replacement approach that improves the efficiency and the reliability of the system while reducing long-term operational costs. A comprehensive and effective plan incorporates a detailed asset inventory, operation and maintenance objectives, and a long-range financial planning strategy.

While the core of asset management refers to the physical infrastructure components of water and wastewater utilities, any successful asset management plan must also account for the financial and human elements involved. Therefore, an effective strategy needs to include assurances that educated, adequately trained, and certified personnel (licensed operators) supervise and implement utility operation. This includes recognition that adequate succession planning is essential to assure the long-term viability of any utility. Financially, water systems must have sufficient revenue to support normal

operation and maintenance, capital projects (using reserves, current revenues or debt financing), and reserves to address emerging needs, revenue instability and emergencies.

Implementation of sound asset management strategies will play a major role in enhancing New Jersey's public health, environment, and economy. DEP encourages asset management through rules and the ensuing permit requirements. To assist with this, guidance documents are provided to clarify permit requirements, in order to ensure best management practices for governing water system maintenance, operation, and management. With this information, system managers will be able to provide a detailed inventory of assets, a condition assessment, calculations for the useful remaining life of infrastructure assets, and long-term capital operating plans. Detailed information about asset management can be found at DEP's Asset Management webpage: DEP Asset Management.

USING THE DEP CAPACITY DEVELOPMENT PROGRAM TO IDENTIFY PROBLEM SYSTEMS

The Environmental Protection Agency's Drinking Water Infrastructure Needs Survey and the Gap Analysis Report begins to estimate the potential needs and financial shortfalls in developing and maintaining overall infrastructure but does not attempt to identify and quantify individual system problems. For that purpose, DEP administers the Capacity Development (CapDev) Program. The Program is a mandate of the 1996 Federal Safe Drinking Water Act (SDWA) amendments and is a tool to accurately identify specific water systems with technical, managerial, and financial (TMF) deficits. The CapDev program provides targeted systems with the tools needed to overcome their shortcomings and to assure long-term system viability.

The 1996 SDWA amendments focused on a public water system's ability to plan for, achieve, and maintain compliance with all applicable drinking water standards. Section 1420(a) requires states to develop and implement programs to ensure that new systems demonstrate TMF capacity, and section 1420(c) requires states to develop and implement programs to assist existing systems in acquiring and maintaining capacity.

The goals of New Jersey's CapDev program include:

- reducing or eliminating the number of existing public water systems in significant non-compliance with the Federal and New Jersey SDWA rules;
- ensuring that public water systems have adequate technical, managerial, and financial capacity to achieve and maintain compliance with the Federal and NJSDWA Rules, and evaluating the TMF capacity of systems that are to receive funds through DEP's State Revolving Fund; and
- preventing the formation and operation of any new water system (community and non-transient, non-community water systems) that may be non-viable in the future, such as a small customer base.

Every three years, the CapDev program identifies a list of non-compliant water systems that require assistance to resolve associated TMF issues. The list is developed with input from DEP's Compliance and Enforcement section and county health departments, utilizing EPA's Enforcement Targeting Tool.

New Jersey's Capacity Development Strategy includes evaluating systems based on the capacities described below.

- **Technical capacity**: ensures adequate knowledge of source and infrastructure needs, adequate operation and maintenance of the system by qualified personnel, and oversight by a system operator of the proper license and classification. There should be adequate source and backup capacity, treatment, auxiliary power, and a properly inspected storage facility.
- **Managerial capacity**: ensures that the water system has clear ownership, proper and organized staffing (including personnel expertise to operate the system), and effective interaction with regulators and with customers.
- **Financial capacity**: ensures that the system has sufficient revenues, credit worthiness, and fiscal management/controls to cover the cost of operating, maintaining, and improving the water system. The water system needs to adequately charge for water, be metered and have a shut-off policy for non-payment.

Finally, there is a continuing focus on asset management as a central tool in developing long-term planning for affected water systems to help implement TMF and long-term planning and viability. Various technical assistance and training contracts are administered by the CapDev program to share the various tools needed to manage the water system. More information on this program is at: DWSG Capacity Development Program.

INFRASTRUCTURE FINANCING

Providing safe, abundant drinking water requires heavy capital investment. Building environmental infrastructure is expensive and the costs are ultimately borne by ratepayers and taxpayers. Low-interest financing from the New Jersey Water Bank has helped keep costs to the public as low as possible. The Department promotes utilization of the Water Bank to local water systems as a cost-efficient way to finance capital water projects, in partnership with the New Jersey Infrastructure Bank ("New Jersey I-Bank"). The New Jersey I-Bank was originally created by legislation enacted in 1986 to establish an independent State authority (originally as the New Jersey Environmental Infrastructure Trust) to manage efficient and low-cost financing for environmental infrastructure projects.

The two agencies partner to provide low-cost funding to finance critical projects including the construction and enhancement of safe drinking water infrastructure through the New Jersey Water Bank. Qualified projects enhance and protect ground and surface water resources, ensure the safety of drinking water, and facilitate responsible, sustainable economic development. They make and administer loans for environmental infrastructure and ensure that the State's water infrastructure -- which is critical in protecting public health, water quality, and the State's natural resources - is properly constructed to State and federal standards.

DEP's Bureau of Water System Engineering jointly manages the DEP's State Revolving Fund (from federal grants under the Safe Drinking Water Act) program with DEP's Municipal Finance and Construction Element and the New Jersey I-Bank. Leveraging by the New Jersey I-Bank (i.e., the sale of revenue bonds,

the proceeds of which are used to fund the New Jersey I-Bank's portion of project loans), allows the State to provide low interest loans to more projects.

The Federal SDWA Amendments of 1996 authorized the DWSRF to assist both publicly and privately owned community water systems and nonprofit noncommunity water systems to finance the costs of infrastructure needed to achieve or maintain compliance with SDWA requirements and to protect the public health in conformance with the objectives of the SDWA. In addition to assessing New Jersey's infrastructure needs, the Drinking Water Infrastructure Needs Survey (discussed previously in this section) is used as the basis to determine the amount of the federal grants allocated to each State's DWSRF program.

Section 1452 (b) of the SDWA requires each State to prepare an Intended Use Plan (IUP) annually to identify the use of funds in the DWSRF and describe the planned use of its allotment of federal funds authorized by the SDWA Amendments. The IUP details how the State of New Jersey finances projects to be included in New Jersey's Water Bank Program and which projects are reviewed by DEP, with respect to the capitalization grant. The non-project set-asides provide for DWSRF activities that are not construction related, including administration of the DWSRF, technical assistance for small systems, State public water system supervision (PWSS) programs, source water program administration, capacity development, and operator certification. Project expenditures involve loans made by the DWSRF to water systems for the planning, design, and construction of drinking water facilities. The most recent IUP can be found at DEP WIIP Intended Use Plan and Project Priority Lists.

DEP's portion of a DWSRF loan provides a portion of the allowable project cost interest-free, with the possibility of principal forgiveness (i.e., loan funds that need not be repaid). The New Jersey I-Bank loan covers the remaining portion of the project's allowable cost at the New Jersey I-Bank's AAA-rated market rates, through the issuance of bonds secured with DWSRF funds. Through leveraging by the New Jersey I-Bank, the State is able to fund far more projects than would be possible with the federal grants alone. States are required to provide matching contributions equal to 20% for the USEPA's annual capitalization grants. The "Water Supply Bond Act of 1981" Bond Fund has been used for the source of match monies. It should be noted that the 1981 Water Supply Bond Act authorized financing only to publicly owned systems, and the federal 1996 SDWA amendments did not change this state law. In FFY2014, New Jersey developed a small systems loan program ("NANO") leveraged by the New Jersey I-Bank to assist systems serving populations of 10,000 or less with their capital infrastructure needs. The NANO Loan Program is limited to $4 million per annum and a portion of each loan is issued as principal forgiveness.

Funds available to the State for future appropriations will be allotted according to a formula that reflects the results of the Drinking Water Infrastructure Needs Survey conducted pursuant to Section 1452(h) of the SDWA. The DWSRF allotment to New Jersey for FFY2014 to 2017 was 1.90 percent of the Federal DWSRF appropriation and was based on the results of the 2011 Drinking Water Infrastructure Needs Survey, published in June 2013. A gradual decrease since the 1997 Needs Survey (1995 data) in New Jersey's DWSRF allotment (from 2.44% to 1.90%) occurred as New Jersey's reported percentage of the total national needs decreased. Based on the 2022 Drinking Water Infrastructure Needs Survey, published in April 2023, New Jersey's share of national estimated needs is now 1.96 percent, a slight increase. While

the DWSRF has provided New Jersey water systems with a relatively stable funding source for the past decade, it is important to recognize that it cannot be the sole source of funding and that individual systems must be prepared to fund projects through other means. The continued involvement of the water systems in New Jersey's Needs Surveys is critical if the State is to receive its fair share of future DWSRF allotments.

For the past 36 years, DEP and the New Jersey I-Bank have focused on cost and operational efficiencies to leverage State and federal funds through New Jersey I-Bank's publicly issued bonds that provide the lowest possible interest rate loans to Financing Program participants for the construction of environmental infrastructure projects. From 1998 to June, 2022, the DWSRF Program provided long-term loan funding for approximately 430 projects totaling $1.625 billion, utilizing federal capitalization grants, loan repayments, interest earnings, State match monies, Trust-leveraged funds, and funds transferred from the Clean Water SRF Program (CWSRF). Thanks to a combination of low interest rates, principal forgiveness funds, and other cost saving features, from 1998 through June 2022, the Drinking Water component of the Water Bank has saved New Jersey ratepayers and taxpayers over $460 million.

The Water Bank Program has been averaging $59 million per year of funding for the construction of substantial drinking water treatment and distribution improvement projects, using federal capitalization grants from the USEPA at approximately $16 million annually.

The Water Bank however has recently been able to significantly enhance its funding capacity thanks to the enactment of the Bipartisan Infrastructure Law (BIL). This law provided $55 billion nationwide to support water projects, ranging from lead service line replacement, treatment for emerging contaminants, improve system resiliency, among many others. Of this, the New Jersey Water Bank is expected to receive $1 billion over the five-year appropriation of the BIL.

With the recent influx of money to support water infrastructure from the BIL, among other sources, the Department initiated the Water Infrastructure Investment Plan (WIIP). The WIIP is intended to highlight the availability of this low-cost funding to eligible borrowers, and defray the cost maintaining, and improving New Jersey's water infrastructure to its ratepayers.

The Water Bank program also administers the State's Clean Water State Revolving Fund (CWSRF). The Clean Water component of New Jersey's EIFP provides low interest loans to publicly-owned sewer systems for planning, design and construction of wastewater treatment facilities and other water quality improvement projects under the Federal Clean Water Act and State law. The CWSRF program is covered under a separate Priority List in DEP's joint DWSRF-CWSRF IUP. Prospective project sponsors complete a project information page that is ranked by DEP and included in the respective Priority Lists as a condition of eligibility for financing.

PROTECTION OF SOURCE WATERS

As discussed earlier in this appendix, DEP has an extensive program for planning, management and regulations of potential pollution threats to ground and surface waters. However, the increase in Harmful Algal Blooms, nonpoint source pollution and incidence of source water contamination from emerging

contaminants of concern all indicate that further action is needed. DEP has been evaluating options for consideration in regulatory and non-regulatory programs, collaboration with other entities, and guidance for potential pollutant sources.

New development creates nonpoint source pollution that is subject to design requirements for soil erosion and sediment control during construction, and for stormwater management during and after construction. These requirements are technology-based to achieve some pollutant control, but they are not water-quality based in the same manner as NJPDES wastewater treatment plant permits. In addition, the technology-based requirements are the same regardless of whether the stormwater discharges to a stream that meets or does not meet the surface water quality criteria. These requirements only apply to new development; they do not apply retroactively to the vast areas of existing development. One option would be to vary the stringency of requirements for new development and redevelopment based on the existing water quality conditions, so that polluted waters are protected from further pollution. Another option would be to provide incentives for developers to improve existing water quality through both on-site and off-site pollutant control projects.

Agricultural practices have greatly improved from the mid-1900s but still, and perhaps inevitably, result in the movement of pollutants (e.g., fertilizers, pesticides, soil particles) into both ground and surface waters. Pesticide applications are regulated to minimize water quality pollution, primarily through a training and certification process. Fertilizer and soil erosion practices are encouraged through farmer education, but there are no specific regulatory requirements. The emphasis is on convincing farmers that excess or inappropriate nutrient use and application, and excessive soil erosion, are damaging to the long-term net profit of the farm and therefore against the farmer's interest. One option is to enhance both farmer education and the underlying research efforts showing what practices provide the greatest long-term net benefits. Agricultural pollutant control efforts could be targeted to water supply source waters, including use of the NRCS source water protection program through the federal Farm Bill.[8] DEP and the WSAC participated in a process that helped NRCS define source water protection areas where farmers are eligible for additional funding. NRCS is revisiting this process and may expand these regions modestly. A key step is to go beyond authorization of funding to a comprehensive implementation project.

Nondegradation policies have achieved benefits for water quality by ensuring that point source pollutant loads do not increase beyond levels permitted at the time of Category 1 or Class GW-1 designation, and by limiting development of undeveloped lands within 300 feet of the Category 1 surface waters (the riparian zone), through the Flood Hazard Area Control Act rules. However, only some water supply source waters are Category 1; in some waters, the automatic connection of Category 1 designation to the riparian zone (buffer) requirements (originally intended for ecological protection) may be inappropriate. While buffers are relatively easy to implement in upstream, less-developed areas, application of Category 1 buffers is more problematic for major river intakes such as New Jersey American's Delran water supply intake on the Delaware River, the Passaic Valley Water Commission intake at Little Falls on the Passaic River, and the New Jersey American intake at Bridgewater on the Raritan River. Applying Category 1

[8] See Source Water Protection | NRCS (usda.gov)

status to protect these waters would trigger buffers for large segments of the state. One option is to develop a nondegradation policy for regional water supply intakes that is tailored specifically to water quality protection, and then to apply the nondegradation to protection of all water supplies.

TMDL application is an important issue for source water protection. DEP has adopted TMDLs (Total Maximum Daily Loads, essentially a water quality improvement plan) for many streams, lakes and ponds, primarily for nutrients and fecal bacteria. Where point sources are required to reduce pollutant loadings, the regulatory process is straightforward. Permits are modified and a compliance schedule is imposed. Nonpoint source reductions are far more difficult and for the most part have been achieved only partly, if at all. Increasing rainfall intensity from climate change will only make success more difficult.

Regarding nutrients, the 2011 Fertilizer Law prohibits use of phosphorus fertilizer unless a soil test shows it is needed, and it regulates the timing and location of fertilizer applications by both consumers and professional applicators. No reports to date demonstrate water quality improvements in phosphorus or nitrogen concentrations; it may be too early but if the Fertilizer Law has been effective, DEP's ongoing ambient water quality results should begin to show results in coming years. To date, phosphorus and total nitrogen reductions have been associated with wastewater treatment plant upgrades and closures (NJDEP, n.d.-a) rather than to the Fertilizer Law.

The DEP provides grants to a wide range of organizations and governmental entities to implement nonpoint source pollution controls, including green stormwater infrastructure, but available funds are a tiny percentage of total needs, including the retrofit of existing stormwater systems to control pollutants. Just as an example, in early 2022, DEP announced nonpoint source pollution grant funding for the years 2020-2022 that totals $9.4 million. In comparison, the New Jersey Department of Transportation announced provision of $47.3 million in 2022 grants for local bridge repairs, only one small part of an annual capital budget of $2.35 billion dollars.

One option is to better harness the existing regulatory and funding programs, and specifically TMDLs, to better protect and restore surface waters that are used for public water supplies. Other states (e.g., Pennsylvania, Minnesota, Virginia, USEPA Region 1 in Massachusetts) have incorporated TMDL provisions in the MS4 permits, requiring municipalities to reduce the stormwater pollutant loads from their MS4s over time. DEP's new MS4 permit has begun this approach, requiring Watershed Improvement Plans to improve water quality from MS4 discharges.

A second option is to focus attention on road runoff that harms surface water quality and stream structure, and work with NJDOT and other transportation agencies to mitigate harm from past road and transportation facility development, not just from new projects.

The **Wellhead Protection Program** provided valuable information on source water risks but could be improved as well. Much more information is available on pollutant source locations and risks than existed 20 years ago, allowing for a better assessment of potential risks. Better protection of the lands that provide water to wells (through aquifer recharge) would be another option. Information on how the areas are defined is available here: NJGS Wellhead Protection Area Delineation Guidelines. Finally, DEP regulatory programs could reassess their regulations regarding protection of public wells.

Finally, the highly successful land preservation programs of DEP Green Acres, the State Agriculture Development Committee, other state agencies, counties, municipalities, water supply agencies and non-profit organizations can be better coordinated to enhance source water protection. First, preservation efforts can be targeted to preservation of critical lands for source water protection, reducing the potential for inappropriate land use changes. Second, the management of preserved lands can be improved to maximize groundwater recharge and minimize pollutant generation and transport to ground and surface waters, such as through agricultural conservation plans and restoration of preserved open lands that have suffered from past land uses.

WATER RESOURCE AND DROUGHT MONITORING AND ASSESSMENT SYSTEMS

There are two critical aspects to understanding water resources management. One is to understand current and past status, which requires measurements, monitoring, modeling and trend analysis. The second is to understand what the future might bring, to the extent feasible given available data, forecasts, projections and modeling methods. We can know history with good information, but we can't change it. We can't know the future, but we can change it, with sufficient insight and planning. The question is how we take an understanding of the past and current times and develop estimates for the future, especially when climate change means that past attributes of temperature and precipitation are no long reliable benchmarks for the future, if indeed they ever were.

DEP, the U.S. Geological Survey and many other parties including water supply utilities have been monitoring New Jersey ground and surface waters for many decades, and they have developed models to assess the data in a useable form, such as safe yields and aquifer withdrawal limitations. This approach is critical to our ongoing ability to understand current status and possible futures. The importance of collecting and properly managing field data is often underestimated. There is nothing more fundamental in water resources management.

AMBIENT AND DROUGHT MONITORING

As indicated in Chapter 5, DEP maintains extensive ambient and drought monitoring networks. The ambient water monitoring program in New Jersey consists of four networks operated by USGS and cooperatively supported by DEP. The networks are described below.

- *The Stream Gauging* Network: collects continuous stage and discharge data at 90 stream stations and low flow data at 36 stream stations. These data are critical for evaluating the impact of water supply allocation decisions.
- *The Groundwater Level* Network: collects water level data from 173 observation wells in all of the major aquifers of the State. It provides long-term status and trends on groundwater resources. It documents climatic and water use influences on these resources. This information is needed for water supply planning and for determination of allocations.
- *The Coastal Plain Synoptic* Network: determines long-term groundwater levels and chloride concentrations in approximately 800 wells in the confined aquifers of the State. Data collection and interpretation are distributed over a five-year cycle. The data are needed for water supply

planning and allocation decisions and serves as an early warning system for salt-water intrusion, overuse of the aquifers of the State, as well as aquifer recoveries noted due to Critical Area allocation cut-backs.

- *The Drought Monitoring* Network: was designed in 2002 using satellite telemetry and provides real-time conditions for streams (43) and groundwater wells (20). Additional stream low flow measurement stations (35) and continuous groundwater well level recorders (19) are also operated. This network provides information throughout the State on ambient conditions for quick response to drought (or flooding) events.

NEW JERSEY WATER TRANSFER DATABASE

The water budgets and availability assessments presented in this Plan are based on statewide and regional analyses, including confined aquifer budgets and HUC11 watershed water budgets. The New Jersey Water Transfer Database (NJWaTr) is used to determine the HUC11 watershed water budgets and water availability estimates and has approximately 38,000 sites, 24,000 conveyances and 2.1 million monthly transfers. These data must be maintained and continuously updated to provide the "living data document" framework envisioned for future water supply planning. This type of ongoing maintenance is necessary in order to support future planning efforts.

Assessments at this scale represent significant advancements from those provided in the previous updates of the NJSWSP (i.e., 150 HUC11s v. 23 Regional Water Resource Planning Areas in the 1996 Plan and 6 planning regions in the 1982 Plan). However, they cannot reflect localized characteristics of the specific locations of the diversions or sub-watersheds (HUC14). This Plan also includes information provided by the much more detailed assessments and modeling efforts conducted by the USGS (under DEP contract) for groundwater systems in the southern portions of the State (e.g., Critical Areas 1 and 2, and the confined aquifers). Like many of the other water supply monitoring programs, the NJWaTr Database is primarily funded through the 1981 Water Supply Bond Fund.

PUBLIC OUTREACH AND EDUCATION

Much of water supply management happens within DEP and water supply utilities through standardized processes that don't draw much public attention. However, an educated and aware public is necessary for proper management of water supply resources and delivery systems. In general, people are not aware of the true value and cost of water in all its forms, including water supplies for various purposes. However, people are unlikely to put much attention to these issues when they are not faced with choices to make, such as whether to support or oppose rate increases, preserve important watershed lands, or purchase lawn irrigation systems, plumbing fixtures or appliances that may be more or less water efficient. When the public faces such decisions, they will be more open to learning, though they also may need to make decisions quickly, resulting in less time for learning.

Public outreach and education is difficult administratively as well. Untargeted efforts (that aren't associated with an issue) are hard to sustain, unlikely to be highly beneficial, and are difficult to assess. To the extent that these efforts are by DEP, they do show support of DEP for the issue, which has value. To the extent that schools (for general education of future adults) and water utilities (for education of

customers and ratepayers) undertake education efforts, there will be limited resources and time available to get across key messages. To be cost-effective in the long-term, water supply public education and outreach needs to be strategic, and the tactics need to be collaborative. Continuity of the message is key, something that is difficult to achieve.

This section provides some general ideas for future consideration.

PRIORITIES FOR PUBLIC EDUCATION AND OUTREACH

Based on the literature and prior practice, the following concepts are of greatest importance in the water supply management field.

- **Awareness of the value of water**: This concept includes economic, financial, ecological and personal values of water in its natural state and as provided for public services.
- **Awareness of PCWS functions and costs of service**: Most people do not know the basics of water supply acquisition, storage, treatment and delivery, nor the costs of providing these services. DEP has begun acquiring rate information for most PCWS, which is incorporated by Jersey Water Works into the Jersey WaterCheck data portal.
- **Optimization of outdoor water demands**: While most people will not deliberately waste water for outdoor irrigation purposes, few will understand how to optimize water use through time-of-day controls, soil moisture monitoring, etc.
- **Drought response and support**: Considerable work has been done on the process of drought response, but public outreach and education can be improved through a greater and more strategic use of social media, network spread of information, involvement of water utilities in the education process, etc.
- **Optimization of indoor water demands**: The USEPA WaterSense program and the Energy Policy Act both have greatly improved the efficiency of indoor water use, but more is possible. In this case, education of potential buyers, especially at the point of sale, can help guide people to water efficient fixtures and appliances, including information on the return on investment from more water-efficient purchases.
- **Support for One Water concept**: A more difficult concept for public education is helping people understand that water in nature, water supply resources, drinking water, used water (i.e., wastewater) and stormwater are all part of one cycle involving one resource – water. The One Water concept suggests that management of all forms of water as a single resource can result in optimization of availability for ecological and human uses, with cost efficiencies through collaborative management.
- **Understanding the basis for potential regulatory or policy changes**: Finally, the public needs to understand enough about potential regulatory or policy changes to determine whether they would support or oppose these changes and why, and how to provide ideas for improving the regulatory and policy results.

POTENTIAL APPROACHES

With these objectives, the next question is how DEP could improve the results of public outreach and education regarding water resources, and specifically water supply issue.

- DEP Web Site: DEP's website has been improving over the years, as online technology improves, people more routinely seek information online, and as online meetings and webinars have improved and become common. Continuing improvements and updates are critical to public outreach and education, including routine updates for those who seek information. The website provides a foundation and a commitment of DEP interest in the topic.
- Drought Preparedness: Each drought is different, but all droughts have commonalities. DEP can improve the speed and effectiveness of drought outreach and education by pre-planning and preparing materials in advance of droughts, using lessons from past droughts as to what messaging approaches are most effective. A strategy should be prepared in advance for involvement and use of news and social media, identifying and gaining cooperation from a network of supporting agencies and entities, and funding sources for immediate implementation of the strategy in a drought situation.
- Classroom and Student Education: Public and private grade school and collegiate education are managed by many thousands of individual schools, overseen by the New Jersey Department of Education and the Secretary of Higher Education. DEP can provide information, ideas and materials that would be valued by these entities, using a collaborative process across relevant DEP programs, including divisions of Water Resources Management; Watershed and Land Management; Office of Environmental Justice; Office of Climate Resilience; and Environmental Education. While some of these units have some educational materials on water resources, there is no cohesive approach that works across all divisions and makes it easy for educators to find and use materials across programmatic lines. DEP can also continue working with and supporting water resources concepts within the Sustainable Jersey for Schools program, the New Jersey Higher Education Partnership for Sustainability, and the involvement of universities in New Jersey in the Sustainability Tracking, Assessment & Rating System (STARS) program of the Association for the Advancement of Sustainability in Higher Education.
- General Public Awareness Campaigns: One option to improve public outreach and education is for DEP to routinely collaborate with other programs, such as through statewide education campaigns highlighting national water campaigns, such as Leak Week, A Day Without Water, and Drinking Water Week. By piggy-backing on existing programs that are also used by water utilities and non-governmental organizations, cost-efficiencies can be achieved. In a similar manner, DEP can develop or help develop toolkits for the AmeriCorps Watershed Ambassadors program, local environmental commissions or green teams, and non-governmental organizations on water conservation measures (includes images, social media postings, actions community members can take), in multiple languages, making it easy for others to improve their own educational programs. These can include residential water awareness, water use efficiency, and water conservation materials, along with drought awareness information (e.g., conservation ideas for each step of a drought, status and trends website).

- Strategic Collaborations for Water Use Efficiencies: Saving money while saving water resources can be a strong motivational force and engaging with those who can either improve sales or reduce costs can make use of that incentive. DEP could work with major suppliers and retailers to offer customer education, perhaps allow with plumbing and appliance manufacturers or store rebates and incentives. The New Jersey Builders Association membership has a strong interest in developer and customer selections and design standards for new homes, including indoor and outdoor water use, as does NAIOP-NJ regarding corporate purchases and indoor and outdoor water use. In the agricultural area, the New Jersey Farm Bureau and Rutgers Extension program have a strong interest in agricultural irrigation system designs. AWWA-NJ, with its membership of utility management and staff along with consultants, will be interested in DEP, New Jersey Department of Community Affairs and Board of Public Utilities guidance regarding approaches for using smart metering as an educational tool.
- Water Awareness and Efficiency Tools for Individual Businesses: New Jersey has a strong business sector, including manufacturing, office parks, retail sales, restaurants, golf courses, and many others, all of which have some need for water supplies and face the costs of accessing water services. DEP can work with relevant associations and experts to identify and share cost-effective methods for reducing water demands in a sustainable manner.
- Preparation for new regulations or policy changes: There are several broad DEP policy areas that affect water supply issues, including:
    - Agency Climate Change Action Plans;
    - Interagency Climate Action Work Group; and
    - Standards Work Group.

  DEP would benefit from a standardized and robust approach to public outreach, education and involvement with the development, adoption and implementation of policies within these and other areas. In addition to public understanding of the proposed policies, the approach would include news and social media efforts to help the public understand the background for proposals. These policies all have implications for the One Water and cost issues discussed above. In coming years, potential water supply regulatory or policy changes might include:
    - water allocation rules;
    - water loss accounting;
    - increased beneficial reuse;
    - lawn irrigation system requirements;
    - source water protection; and
    - drinking water MCLs.
- Preparation for local PCWS capital projects: Finally, water utilities are experiencing increased public focus on rate schedules and costs. National experience indicates that the public is more likely to support rate increases if they fully understand how the additional revenues will be used to support capital projects that will maintain or improve critical services, and that the rate schedule distributes costs fairly. Water utilities would benefit from provision of basic educational approaches and materials for use by PCWS (not DEP) to build public understanding of the need for capital projects.

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    DENNIS REINKNECHT

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
OFFICIAL ORGANIZATIONAL CHART
DEPARTMENTAL OVERVIEW

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